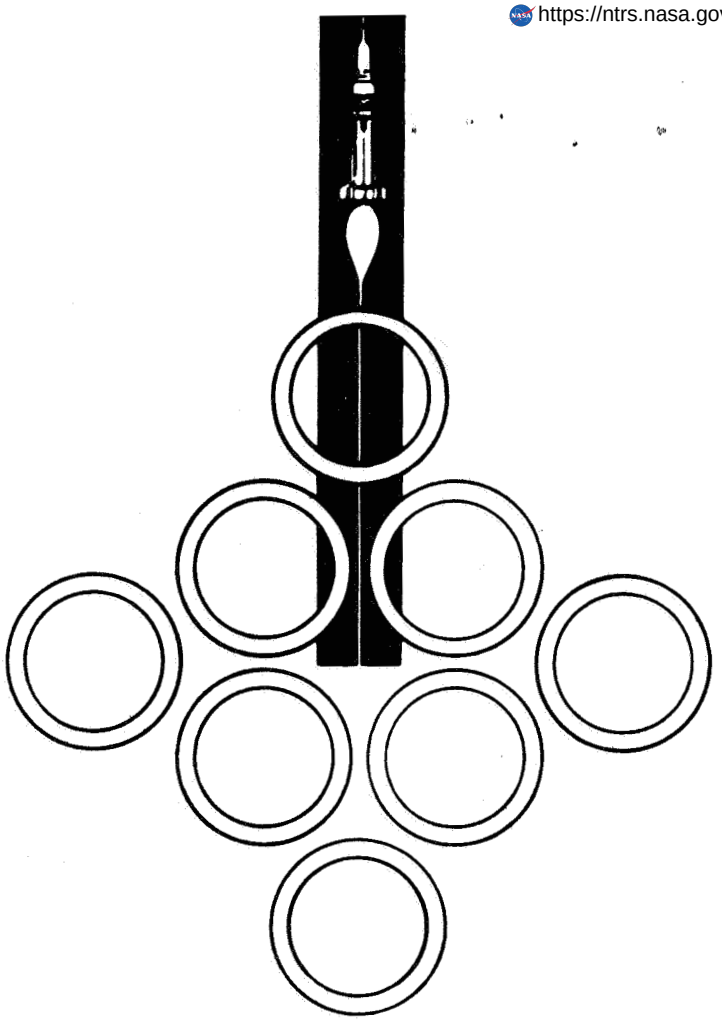


ENGINEERING DEPARTMENT

TECHNICAL REPORT

TR-RE-CCSD-FO-1138-3

April 25, 1968

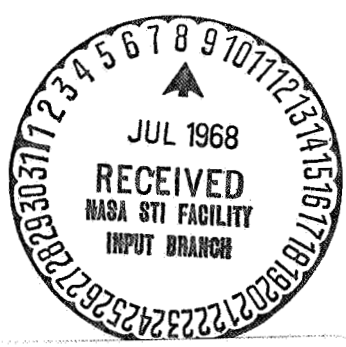
TEST REPORT

FOR

DUAL ROTARY ACTUATOR, 148,500 INCH-POUNDS

Excello Corporation Model Number C15X5X5 IV

NASA Drawing Number 75K26197



SPACE DIVISION CHRYSLER CORPORATION

TEST REPORT
FOR
DUAL ROTARY ACTUATOR, 148,500 INCH-POUNDS
EXCELLO CORPORATION MODEL NUMBER S15X5X5
NASA DRAWING NUMBER 75K26197

ABSTRACT

This report presents the results of tests performed on one specimen of Dual Rotary Actuator 75K26197. The following tests were performed:

1. Receiving Inspection
2. Proof Pressure
3. Functional
4. Vibration
5. Impulse
6. Cycle

The performance of the test specimen was in accordance with the requirements of NASA Drawing 75K26197 throughout the test program with the following exceptions:

1. Static torque developed by each vane in the 5, 25, 50 and 75 percent of rotation positions was below the specified value of 148,000 inch-pounds.

2. Vane leakage, after the initial functional test, exceeded the specified allowable of 75 cc per minute.

3. Breakaway pressure exceeded the specified maximum of 75 psig throughout the test program.

Test Specimen, S/N 46797, was returned to the vendor for a seal modification following the initial functional test. A second specimen, S/N 46798, with the seal modification incorporated was received for test. This report contains the test results obtained on this specimen (S/N 46798).

TR-RE-CCSD-FO-1138-3

TEST REPORT

FOR

DUAL ROTARY ACTUATOR, 148,500 INCH-POUNDS

Excello Corporation Model Number S15X5X5 IV

NASA Drawing Number 75K26197

April 25, 1968

CHRYSLER CORPORATION SPACE DIVISION - NEW ORLEANS, LOUISIANA

FOREWORD

The tests reported herein were conducted for the John F. Kennedy Space Center by Chrysler Corporation Space Division (CCSD), New Orleans, Louisiana. This document was prepared by CCSD under Contract NAS 8-4016, Part VII, CWO 271620.

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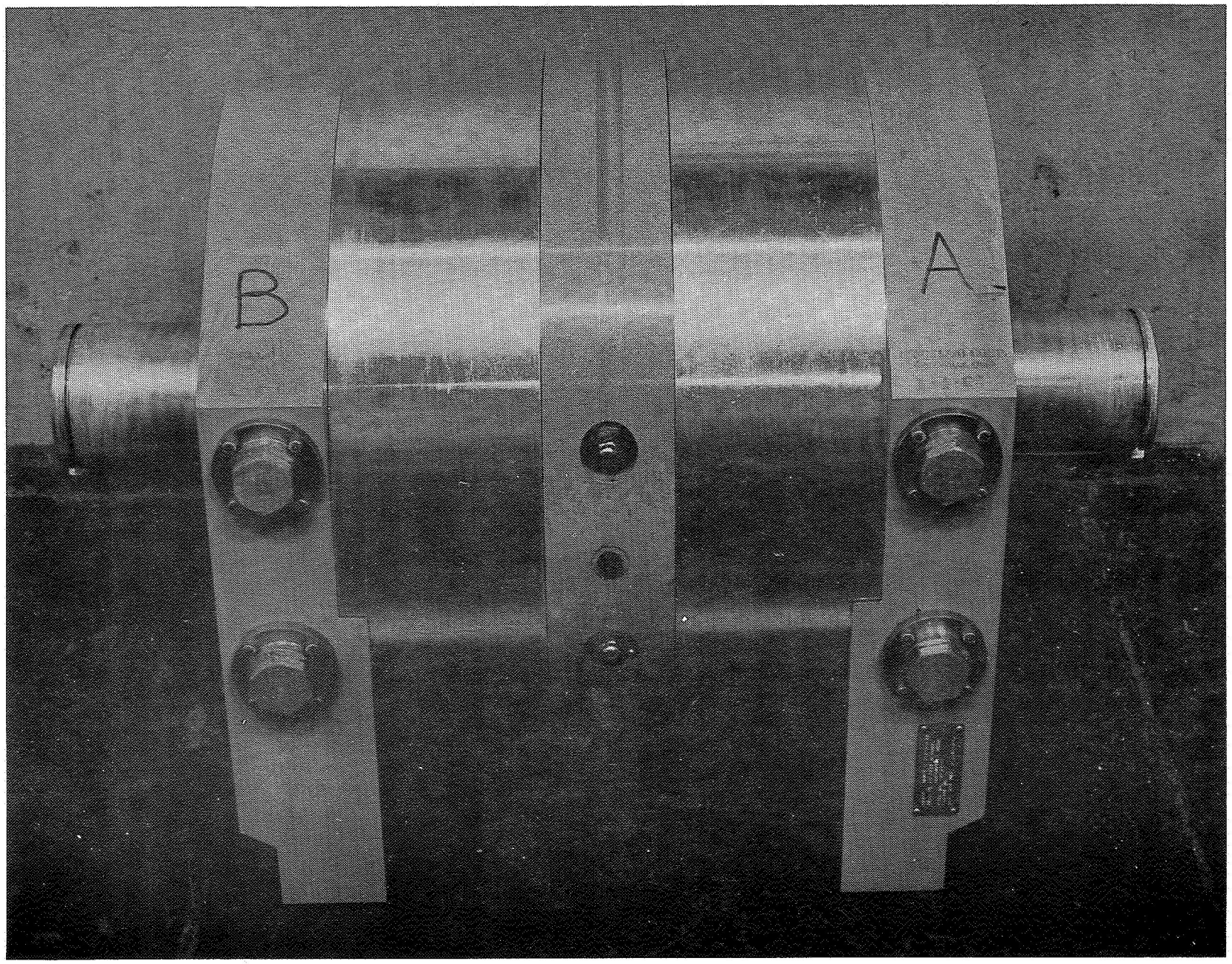


Dual Rotary Actuator, 148,500 Inch-Pounds, 75K26197

CHECK SHEET

FOR

DUAL ROTARY ACTUATOR, 148,500 INCH-POUNDS

MANUFACTURER: Excello Corporation

MANUFACTURER'S MODEL NUMBER: S15X5X5

NASA DRAWING NUMBER: 75K26197

TESTING AGENCY: Chrysler Corporation Space Division, New Orleans, Louisiana

AUTHORIZING AGENCY: NASA-KSC

I. FUNCTIONAL REQUIREMENTS

A. OPERATING MEDIUM: MIL-H-5606

B. OPERATING PRESSURE: 1500 psig

C. LEAKAGE AT 1500 PSIG: Vanes 75 cc/minute

Bearings 10 cc/minute

D. ROTATION: 290°

E. BREAKAWAY PRESSURE: 75 psig max.

II. CONSTRUCTION

A. HOUSING: Aluminum-anodized

B. BOLTS: Steel-cadmium plated

III. ENVIRONMENTAL REQUIREMENTS

OPERATING TEMPERATURE RANGE: 0° to 160°F

IV. LOCATION AND USE: The actuators are used to rotate the umbilical swing arms on Launch Complexes 34 and 37.

TEST SUMMARY
for
DUAL ROTARY ACTUATOR
75K26197

Environment	Units	Operational Boundary	Test Objective	Test Results	Remarks
Receiving Inspection	1	Comply with NASA Drawing 75K26197	Determine compliance with NASA drawing and examine for defects and poor workmanship.	Satisfactory	
Proof Pressure Test	1	3200 Psig	Check for leakage and distortion.	Satisfactory	No leakage or permanent distortion.
Functional Test	1	2250 Psig	Measure static torque developed, leakage, and breakaway pressure. Develop a curve of static torque versus pressure.	Static torque, and breakaway pressure not within specifications.	Static torque below 148,000 inch pounds at vane positions of 5, 25, 50 and 75%. Breakaway pressure exceeded the 75 psig specified maximum.
Vibration Test	1	10 to 35 Cps at 0.08 inch DA. 35 to 2000 Cps at 5.0 g. 10 to 58 Cps at +3 db/ octave. 58 to 400 Cps at 0.06 g^2/Cps. 400 to 2000 Cps at -3 db/ octave.	Determine if specimen operation is impaired by vibration.	Vane leakage increased after vibration.	Vane leakage increased after vibration, but decreased after the specimen was cycled.

TEST SUMMARY (contd.)

Environment	Units	Operational Boundary	Test Objective	Test Results	Remarks
Impulse Test	1	0 to 2250 psig; 35 cycles per minute.	Determine if specimen operation is impaired by pressure impulse.	Satisfactory	
Life Cycle Test	1	1000 cycles each vane.	Determine if specimen operation is impaired by cycling.	Satisfactory	
Final Inspection	1	N/A	Inspect the specimen for wear and damage.	Satisfactory	

SECTION I

INTRODUCTION

1.1 SCOPE

This report presents the results of tests that were performed to determine if Dual Rotary Actuator 75K26197 meets the operational requirements for John F. Kennedy Space Center Launch Complexes 34 and 37B. A summary of the test results is presented on page viii.

1.2 ITEM DESCRIPTION

Dual Rotary Actuator 75K26197 is manufactured by the ExCello Corporation as vendor Model Number S15X5X5. The actuator has separate cavities, vanes and shafts. The actuator has an operating pressure of 1500 psig and developes 148,000 inch-pounds of torque. Operating media is hydraulic fluid. The actuator is 32½ by 20 by 21-inches and weighs 856 pounds.

1.3 APPLICABLE DOCUMENTS

1.3.1 The documents used in this test program are as follows:

a. 75K26197, Component Specification

b. KSC-STD-164(D), Standard Environmental Test Methods for Ground Support Equipment Installations at Cape Kennedy.

c. GP-320, Vibration, Shock and Acoustic Environmental Levels - Launch Complexes 34 and 37, Ground Support Equipment

d. Test Procedure CCSD-FO-1138-2

e. Test Plan CCSD-FO-1138-1, Test Requirements

SECTION II

RECEIVING INSPECTION

2.1 REQUIREMENTS

The specimen shall be visually and dimensionally inspected for conformance with the applicable specifications prior to the start of testing.

2.2 PROCEDURE

2.2.1 A visual and dimensional inspection of the test specimen was performed to determine compliance with NASA Specification, 75K26197, and ExCello Corporation drawing number, SP-1155, to the extent possible without disassembly of the test specimen. The specimen was also simultaneously inspected for poor workmanship and manufacturing defects.

2.2.2 The specimen was weighed.

2.3 TEST RESULTS

2.3.1 The specimen complied with NASA drawing 75K26197 and ExCello Corporation drawing number SP-1155. No evidence of poor workmanship or manufacturing defects was observed.

2.3.2 The specimen weighed 856 pounds.

2.4 TEST DATA

The data presented in table 2-1 were recorded during the inspection.

Table 2-1. Specimen Specifics

Name	Rotary Actuator
Manufacturer	ExCello Corporation
Model	S 15X5X5
Port Sizes	One inch
Shaft Diameter	4½ inches

SECTION III

PROOF PRESSURE TEST

3.1 TEST REQUIREMENTS

The test specimen shall be pressurized with MIL-H-5606A oil to a proof pressure of 3200 psig. This pressure shall be maintained for 5 minutes and the specimen shall be checked for leakage and distortion.

3.2 TEST PROCEDURE

3.2.1 The specimen was installed as shown in figure 3-1 utilizing the equipment listed in table 3-1.

3.2.2 All connections were tight, gages were installed and operating properly, and all valves were closed.

3.2.3 Hand valves 3, 5, and 7 were opened.

3.2.4 Using hand pump 2, oil was pumped, until the system and specimen were free of air.

3.2.5 Hand valves 5 and 7 were closed. The specimen was pressurized to 1000 psig as read on gage 4. Readings on dial indicators 8, 9, and 10 were recorded, leakage was noted. This procedure was repeated at 1500, 2000, 2500, and 3200 psig, and the pressure was maintained at 3200 psig for 5 minutes. The pressure was then vented and all data were recorded.

3.2.6 At zero psig the dial indicators were read to determine if permanent distortion had occurred.

3.4 TEST DATA

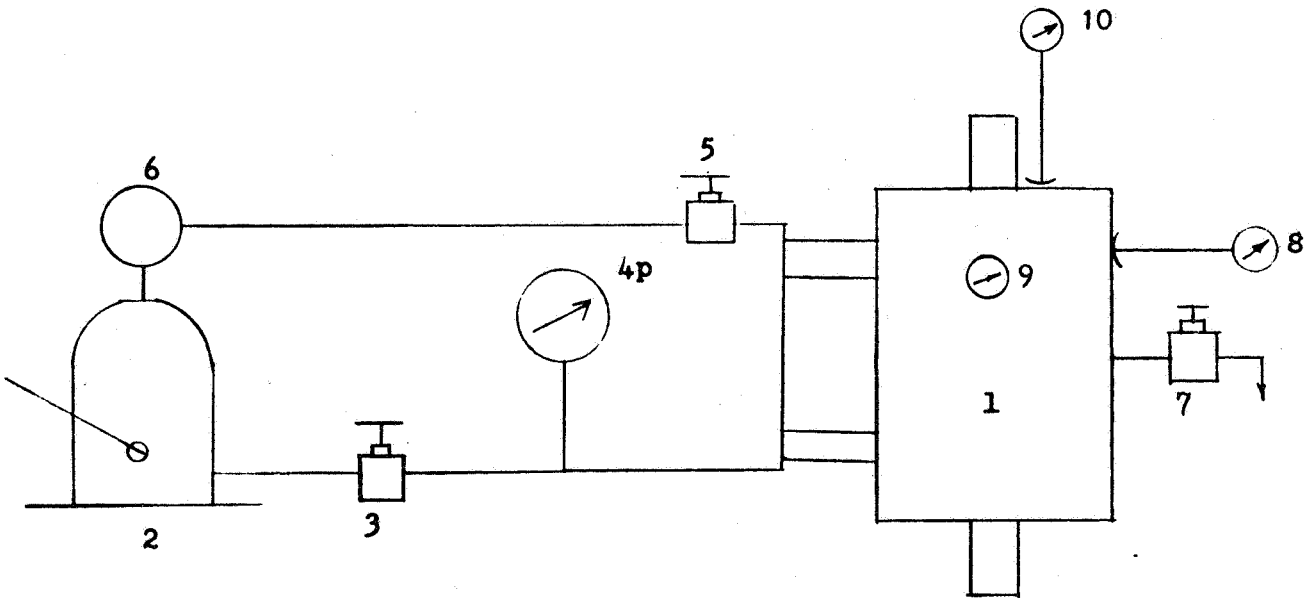
Test data are presented in table 3-2.

Table 3-1. Proof Pressure Test Equipment List

Item No.	Item	Manufacturer	Model/ Part No.	Serial No.	Remarks
1	Specimen	ExCello Corporation	S15X5X5	46798	
2	Hand Pump	W. S. Pine	160-3		0 to 5000 psig
3	Hand Valve	Robbins	SSKG 250-14		$\frac{1}{4}$-inch
4	Pressure Gage	Heise	H-35961	NASA 015537	0 to 5000 psig ±0.1% FS Cal. Date 10-11-67
5	Hand Valve	Robbins	SSKG 250-14		$\frac{1}{4}$-inch
6	Reservoir	CCSD			10-gallon
7	Hand Valve	Robbins	SSKG 250-14		$\frac{1}{4}$-inch
8	Dial Indicator	Brown & Sharp	7283		
9	Dial Indicator	Brown & Sharp	7283		
10	Dial Indicator	Brown & Sharp	7283		

Table 3-2. Proof Pressure Test Data

Pressure (psig)	Leakage cc/min	Expansion (inches)		
		Indicator A	Indicator B	Indicator C
1000	0	0.002	0.000	0.002
1500	0	0.003	0.000	0.006
2000	0	0.005	0.000	0.010
2500	0	0.012	0.000	0.015
3200	0	0.0085	- 0.0005	0.023
0	0	0.000	0.000	0.000



Note: All lines ¼-inch

Refer to table 3-1 for item identification

Figure 3-1. Proof Pressure Test Schematic

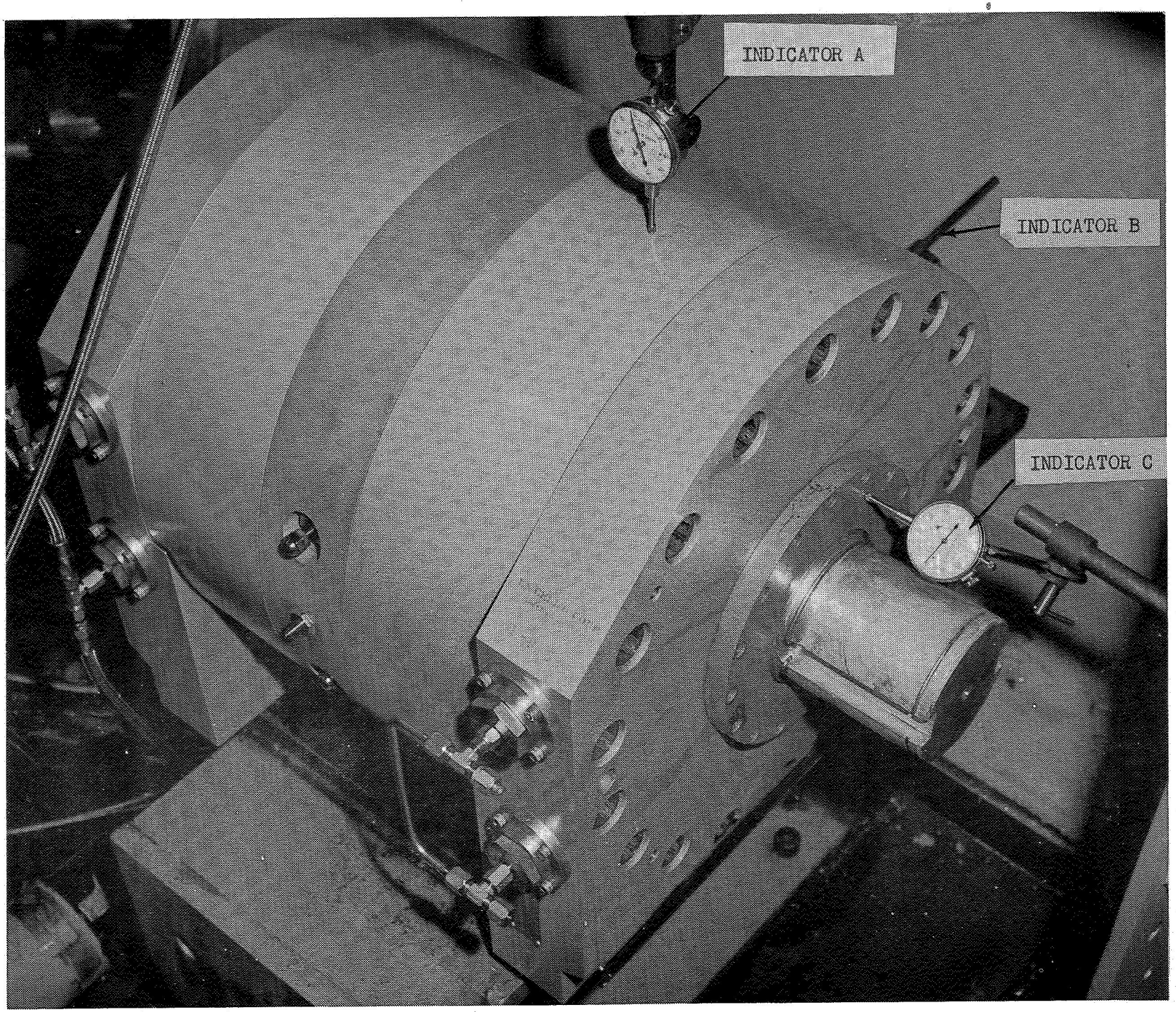


Figure 3-2. Proof Pressure Test Setup

SECTION IV

FUNCTIONAL TEST

4.1 TEST REQUIREMENTS

4.1.1 A functional test shall be conducted to determine specimen breakaway pressure, static torque developed, and bearing and vane leakage.

4.1.2 Using MIL-H-5606A hydraulic fluid as the pressure medium, slowly pressurize the specimen to determine breakaway pressure. This test shall be repeated to obtain consistent data.

4.1.3 Using MIL-H-5606A hydraulic fluid, pressurize one side of the vane to 1500 psig. Measure the static torque developed by the cell. Measure leakage across the vane at rotation positions of 10, 30, 50, 70, and 90 percent and leakage at each bearing.

4.1.4 Plot a curve of shaft torque versus vane pressure. Vane pressure shall be breakaway pressure through 2250 psig.

4.2 TEST PROCEDURE

4.2.1 The specimen was installed as shown in Figures 4-1 and 4-2 utilizing the equipment listed in Table 4-1.

4.2.2 All connections were tight, all gages were installed and operating properly, and all valves were closed.

4.2.3 Solenoid valves 10 and 16, hand valves 3, 9, and 15, and internal port 20 were opened.

4.2.4 Solenoid valve 6 was opened, and using regulator 4, accumulator 7 was pressurized until vane A breakaway occurred. Gage 19 was monitored. Vane A was rotated to the 5 percent position and hand valve 9 was closed. Cable 24 was attached to pully 25.

4.2.5 Hand valves 9 and 18 were opened. Vane B was rotated to the 5 percent position and hand valve 18 was closed.

4.2.6 Using regulator 4, Vane A was pressurized until 1500 psig was indicated on gage 19.

4.2.7 Solenoid valve 16 was closed and the leakage and load cell output were recorded.

4.2.8 Solenoid valve 6 was closed and accumulator 7 vented.

4.2.9 Solenoid valve 12 was opened and accumulator 13 pressurized to vane A breakaway to relieve tension in cable 24.

4.2.10 Procedures 4.2.4 through 4.2.9 were repeated at the 25, 50, 75, and 95 percent positions on vanes A and B.

4.2.11 Both vanes were rotated to the 50 percent position and cable 24 was attached to pully 25.

4.2.12 Vane A was pressurized to 2250 psig in 250 psig increments. Static torque and leakage at each increment were recorded.

4.2.13 A curve was plotted for torque versus pressure.

4.3 TEST RESULTS

4.3.1 Torque developed by vane A ranged from 134,900 inch-pounds to 156,500 inch-pounds over different vane positions. Torque developed by vane B ranged from 132,100 inch-pounds to 151,000 inch-pounds.

4.3.2 Leakage by vane A ranged from 14 cc per minute to 60 cc per minute, and from 80 cc per minute to 180 cc per minute by vane B.

4.3.3 A breakaway pressure of 200 psig was recorded on vane A and 145 psig on vane B.

4.4 TEST DATA

Test data are presented in Tables 4-2 and 4-3. A characteristic curve of torque versus pressure is presented in Figure 4-3.

Table 4-1. Functional Test Equipment List

Item No.	Item	Manufacturer	Model/ Part No.	Serial No.	Remarks
1	Test Specimen	Excello	S 15X5X5	46798	
2	GN_2 Supply				Laboratory Source
3	Hand Valve	C.P.V.			1-inch
4	Pressure Regulator	Grove	18	L-43046	0 to 6000 psig
5	Gage	Ashcroft		200489-0	0 to 5000 psig Cal. Date 10-1-67
6	Solenoid Valve	Marotta	MV-74	146	
7	Accumulator	Greer Hydraulics	SA-372		3000 psig
8	Gage	Maximon		1231-B	0 to 3000 psig Cal. Date 10-1-67
9	Hand Valve	Robbins	SSKG-375-B		1-inch
10	Solenoid Valve	Marotta	MV-583-H	913	
11	Hand Valve	Robbins	SSKG-250-14		
12	Solenoid Valve	Marotta	MV-74	13766	
13	Accumulator	Greer Hydraulics	SA-372		3000 psig
14	Gage	Marsh	100-45	1202-B	0 to 3000 psig Cal. Date 11-3-67
15	Hand Valve	Robbins			1-inch
16	Solenoid Valve	Marotta	MV-583-H	912	
17	Graduated Cylinder	Kimax			100 cc
18	Hand Valve	Robbins	SSKG-250-14		$\frac{1}{4}$ inch

Table 4-1. Continued

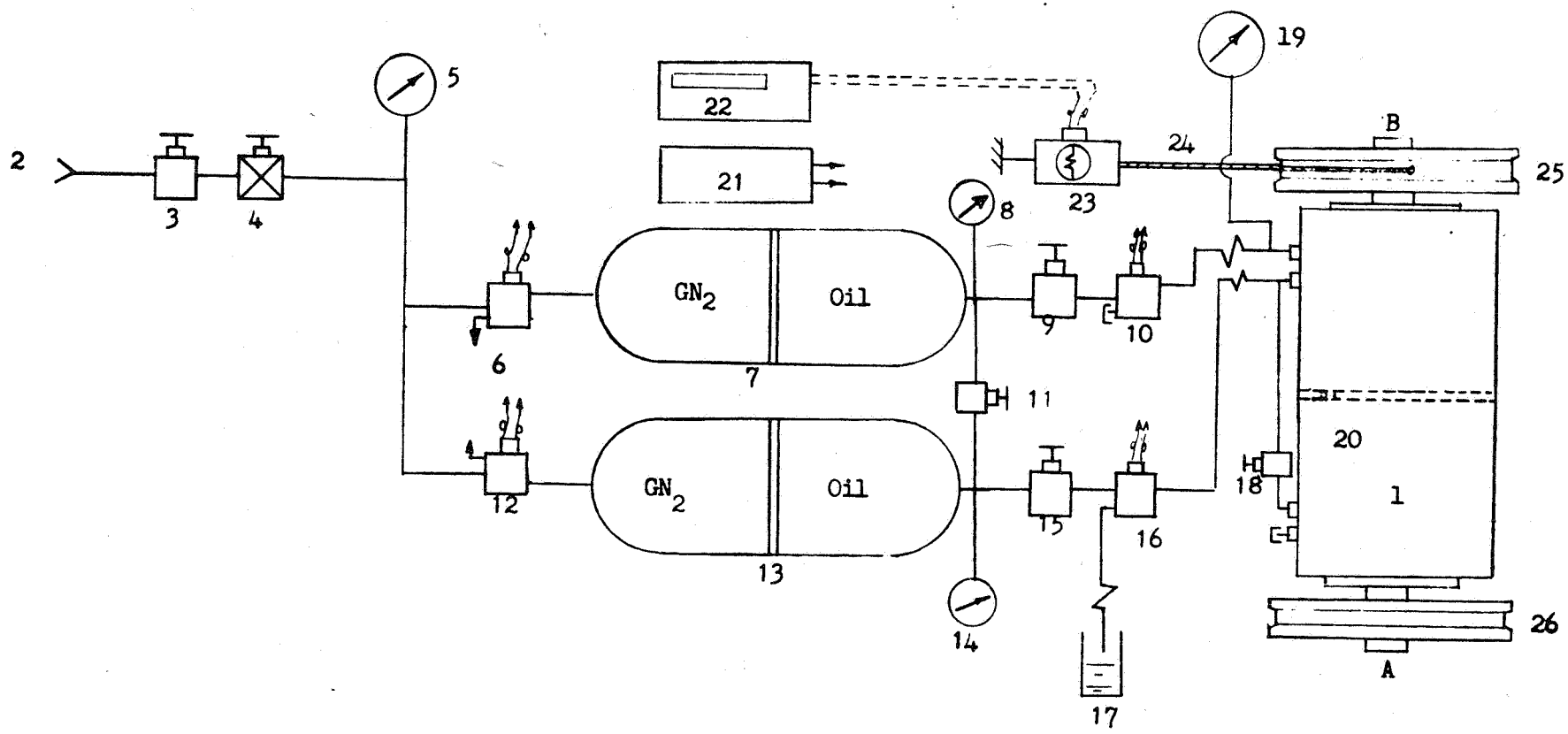
Item No.	Item	Manufacturer	Model Part No.	Serial No.	Remarks
19	Gage	Heise	H-35961	015537	0 to 5000 psig Cal. Date 10-5-67
20	Transfer Port				Part of Test Specimen
21	Power Supply	Q-Nobatron	QR 36-4A	015450	0 to 32 VDC
22	Digital Volt-meter	Vidar	510	017921	Cal. Date 8-6-67
23	Load Cell	Revere	C-45618	144650	15000 pound Cal. Date 10-1-67
24	Cable				5/8 inch
25	Pulley	CCSD			12 inch radius
26	Pulley	CCSD			12 inch radius

TABLE 4-2. INITIAL FUNCTIONAL TEST DATA

Vane Pressure (Psig)	Vane Position (% Rotation	VANE A			VANE B		
		Torque (inch-pounds)	Leakage (cc/minute)	Breakaway (psig)	Torque (inch-pounds)	Leakage (cc/minute)	Breakaway (psig)
1500	5	148,500	14		144,600	90	
1500	25	135,900	25		140,100	180	
1500	50	134,900	25	200	132,100	120	145
1500	75	147,500	60		142,000	80	
1500	95	156,500	35		151,000	80	

TABLE 4-3. CHARACTERISTIC TEST DATA

Vane Pressure (Psig)	Vane Position (% Rotation)	VANE A		VANE B	
		Torque (inch-pounds)	Leakage (cc/minute)	Torque (inch-pounds)	Leakage (cc/minute)
250	50	20,250	2	14,000	0
500	50	44,650	4	36,810	0
750	50	69,600	8	60,950	26
1000	50	95,100	12	85,500	52
1250	50	120,500	16	110,500	100
1500	50	145,500	20	134,900	105
1750	50	170,000	34	159,000	470
2000	50	193,500	180	184,300	1100
2250	50	215,000	700	208,100	3000



Note: All Hydraulic lines 1-inch
Pnuematic lines ¼-inch
Refer to Table 4-1 for item identification

Figure 4-1. Functional Test Schematic

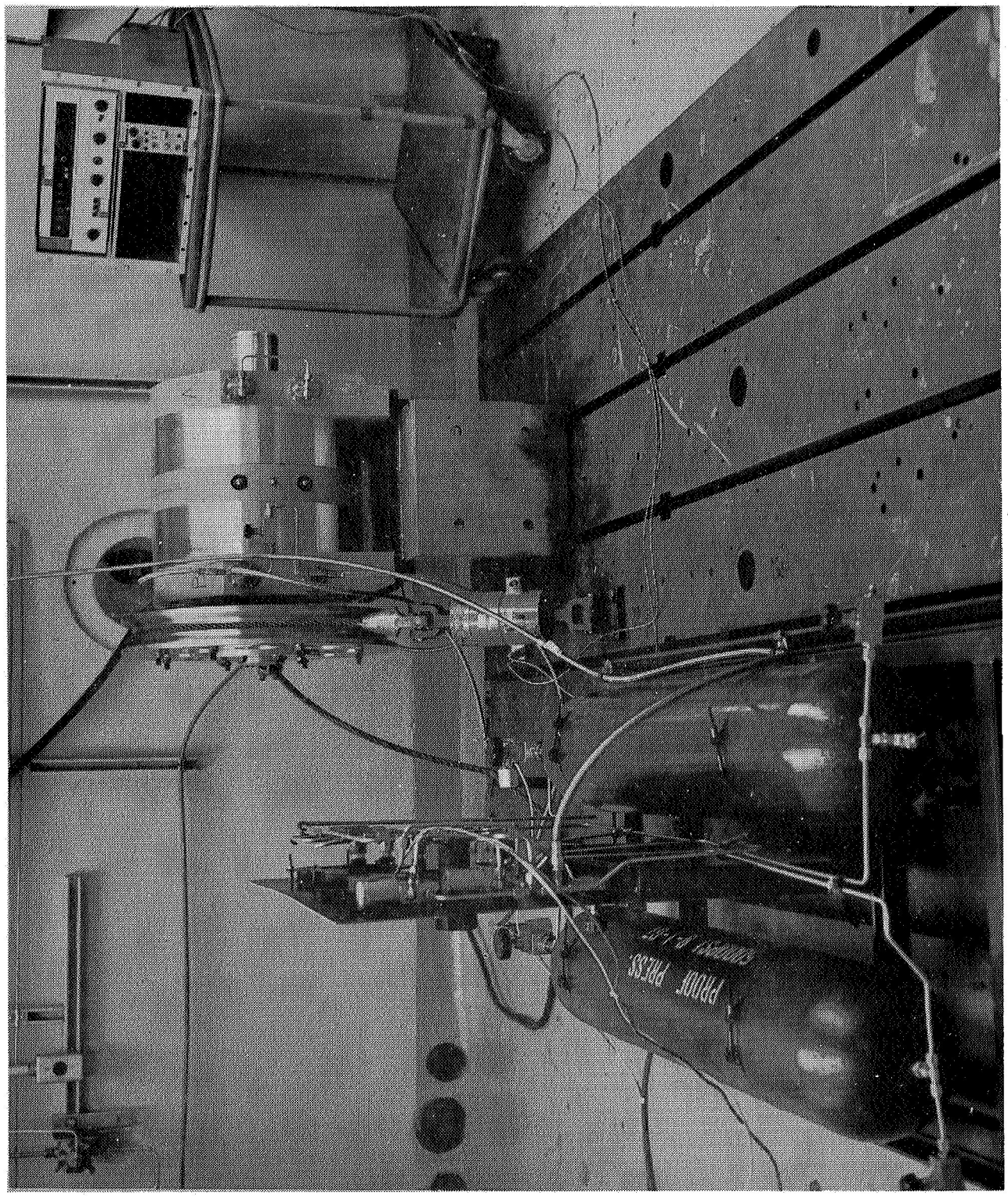


Figure 4-2. Functional Test Setup

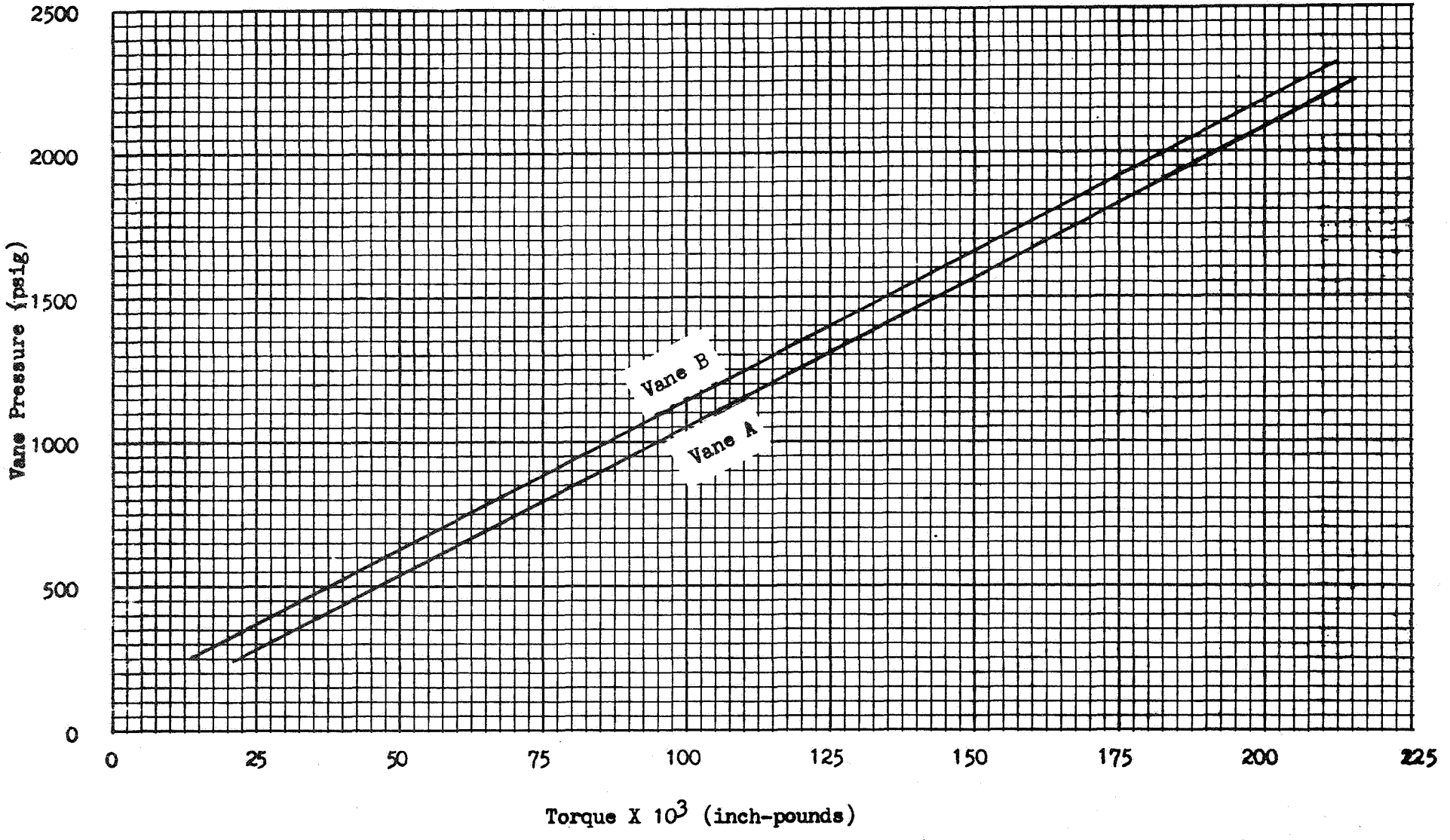


Figure 4-3. Characteristic Curve - Torque Versus Vane Pressure

SECTION V

VIBRATION TEST

5.1 TEST REQUIREMENTS

5.1.1 A vibration test shall be performed on the specimen while both cells are pressurized to 1500 psig with MIL-H-5606A hydraulic fluid. Vibration shall be applied along three mutually perpendicular axes. The test shall be performed in accordance with KSC-STD-164(D) Section 9, Procedure 1, to the levels specified in GP-320, Zone 3-1.

5.1.2 SINUSOIDAL SWEEP

5.1.2.1 In one 20-minute sweep, the frequency range shall be scanned logarithmically from 10 to 2000 to 10 cps. Critical frequencies of the test specimen shall be noted. The sinusoidal sweep input levels shall be as shown in table 5-1.

Table 5-1. Sinusoidal Sweep Vibration Levels

Frequency (Hz)	Displacement (inch DA)	Acceleration (g)
10 to 35	0.08	-
35 to 2000	-	5.0

5.1.3 RANDOM EXCITATION

5.1.3.1 The test specimen shall be exposed to random vibration at the specified levels over a frequency range from 10 to 2000 Hz for a period of 5 minutes. The specified random input levels shall be as shown in table 5-2. The specimen shall be operated during the final seconds of exposure.

Table 5-2. Random Excitation Vibration Levels

Frequency (Hz)	Slope (db/octave)	PSD (g^2/Hz)
10 to 58	+3	-
58 to 400	-	0.06
400 to 2000	-3	-

5.1.4 Acceleration shall be measured at the test assembly by accelerometers mounted on the assembly.

5.1.5 The vibration test shall be conducted in three mutually perpendicular axes. The previously described testing is for one axis and shall be completed before proceeding to the next axes.

5.2 TEST PROCEDURE

The test specimen was mounted on the vibration system for vibration as shown in figures 5-1, 5-2, and 5-3 utilizing the equipment listed in table 5-3.

5.2.2 The specimen was filled with MIL-H-5606A hydraulic fluid and all air was bled from the system.

5.2.3 Hand valves 3, 9, and 14, solenoid valve 11 and the specimen cross ports were opened.

5.2.4 Accumulator 7 was utilized and the specimen was pressurized to 1500 psig. This pressure was maintained during all periods of vibration. Solenoid valve 16 was opened and the specimen vanes were rotated during random vibration.

5.2.5 Following completion of vibration testing, in the X, Y, and Z axes, a functional test was performed.

5.2.6 All test data were recorded.

5.3 TEST RESULTS

The specimen withstood vibration testing with no external leakage. Post vibration functional testing however revealed that the leakage by vane A was 700 cc per minute and 720 cc per minute by vane B. The torque developed was lower than initial functional results and breakaway pressures were higher.

5.4 TEST DATA

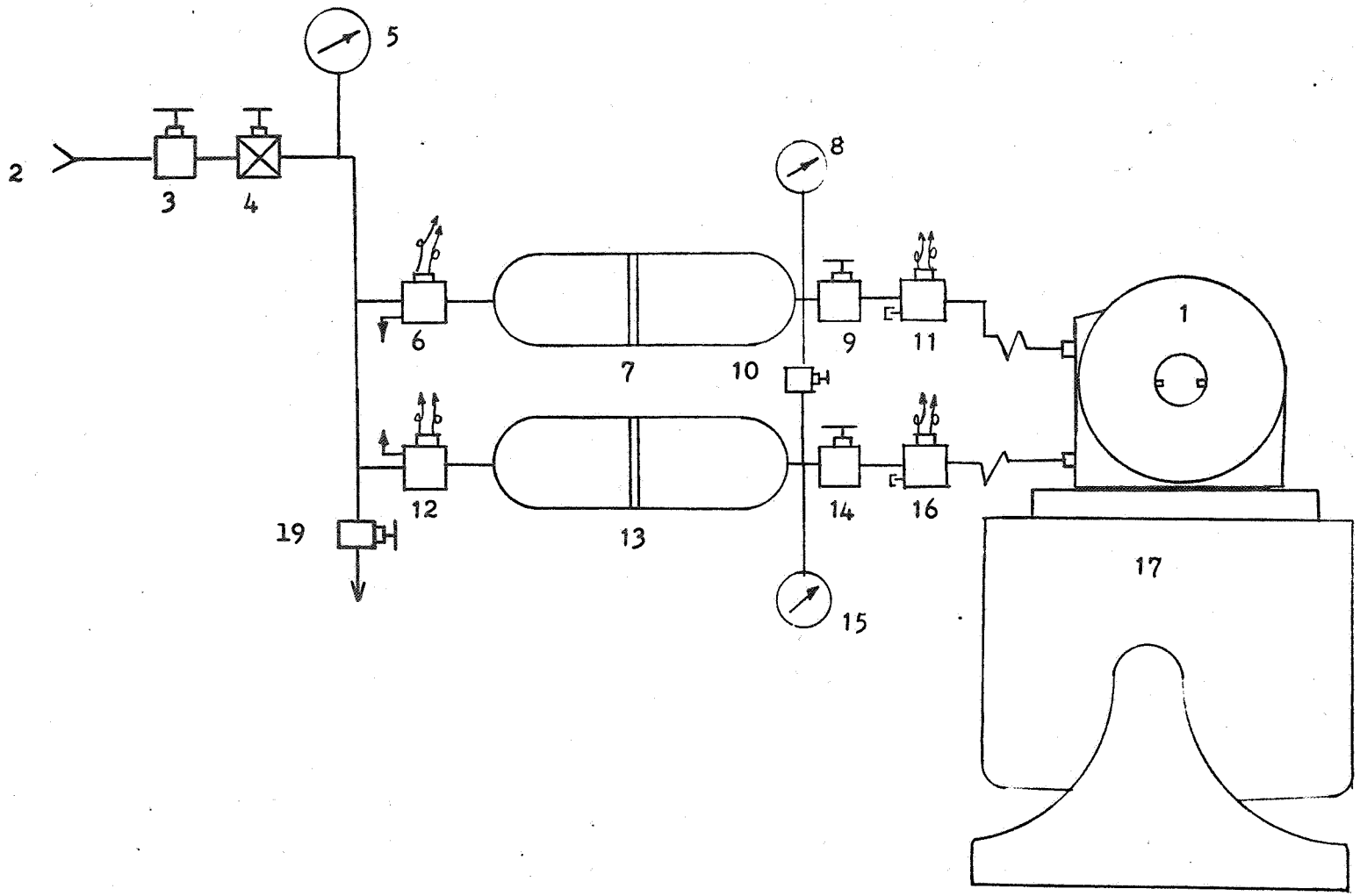
Test data are presented in Table 5-4. Typical sinusoidal sweep and random equalization plots are presented in Figures 5-4 and 5-5.

Table 5-3. Vibration Test Equipment List

Item No.	Item	Manufacturer	Model Part No.	Serial No.	Remarks
1	Test Specimen	ExCello Corp	S15X5X5	46798	
2	GN_2 Supply				
3	Hand Valve	CPV			1-Inch
4	Pressure Regulator	Grove	18	L-43046	0 to 6000 psig
5	Gage	Ashcroft		NASA 200489-0	0 to 5000 psig Cal. Date 10-1-67
6	Solenoid Valve	Marotta	MV-74	146	
7	Accumulator	Gree Hydraulics	SA-372		
8	Gage	Maximom		NASA 1231-B	0 to 3000 psig Cal.Date 10-1-67
9	Hand Valve	Robbins	SSKG 375-B		1-Inch
10	Hand Valve	Robbins	SSKG 250-14		1/4-Inch
11	Solenoid Valve	Marotta	MV-583H	913	
12	Solenoid Valve	Marotta	MV-74	13766	
13	Accumulator	Greer Hydraulics	SA-372		
14	Hand Valve	Robbins Aviation	SSKG 375B		1-Inch
15	Gage	Marsh	100-4S		0 to 3000 psig Cal.Date 11-3-67
16	Solenoid Valve	Marotta	MV-583H	912	
17	Vibration Exciter	MB	C-210		
19	Hand Valve	Robbins	SS KG 250-14		1/4-Inch

TABLE 5-4. POST VIBRATION FUNCTIONAL TEST DATA

Vane Pressure (Psig)	Vane Position (% Rotation)	VANE A			VANE B		
		Torque (inch-pounds)	Leakage (cc/minute)	Breakaway (psig)	Torque (inch-pounds)	Leakage (cc/minute)	Breakaway (psig)
1500	5	130,100	540		127,700	720	
1500	25	124,000	600		117,800	720	
1500	50	123,900	600	220	123,500	350	320
1500	75	139,200	700		136,800	250	
1500	95	153,600	550		152,100	225	



Note: All pneumatic lines $\frac{1}{4}$-inch
All hydraulic lines $\frac{1}{2}$-inch
Refer to table 5-1 for item identification

Figure 5-1. Vibration Test Setup

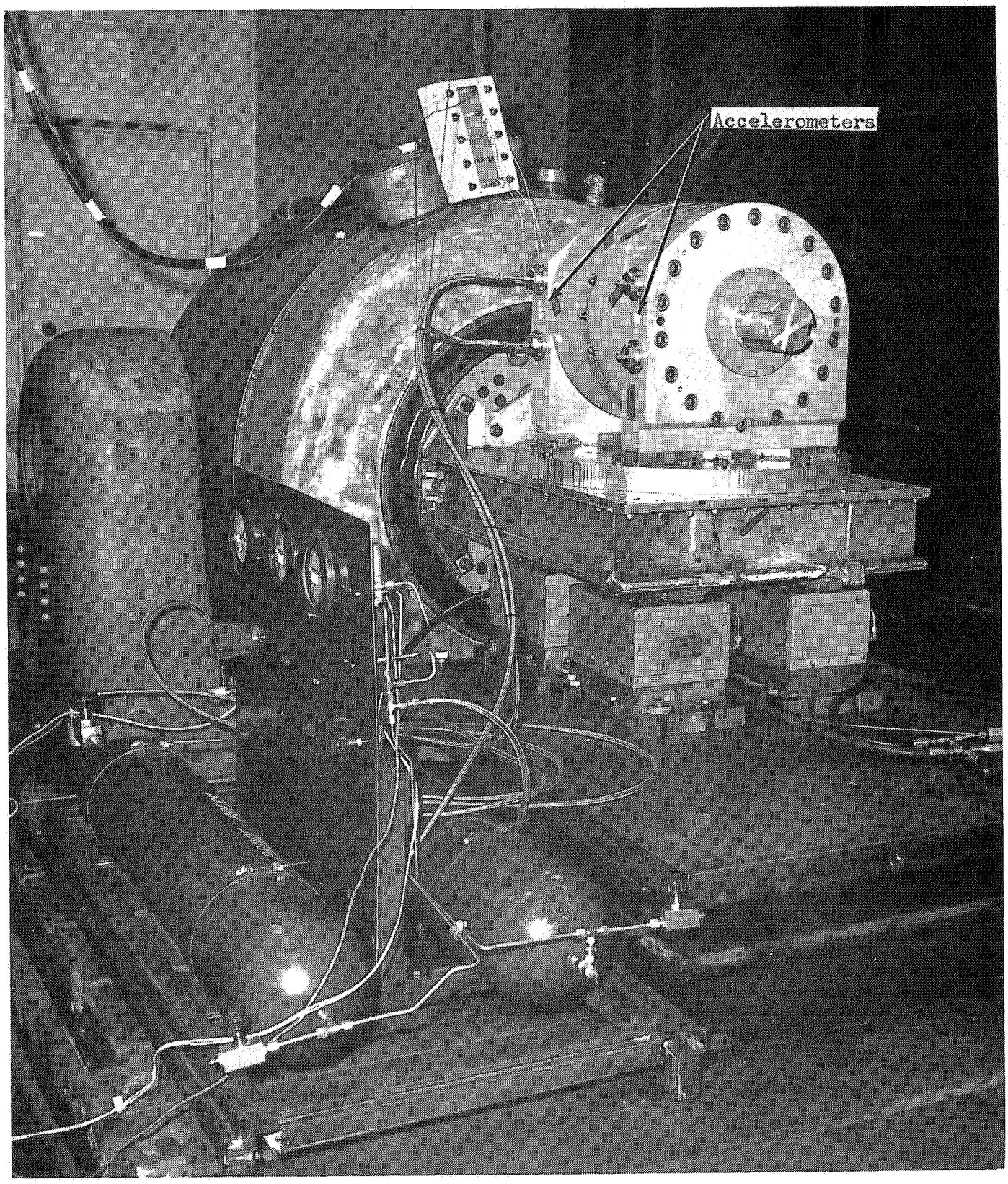


Figure 5-2. Vibration Test Setup, X-Axis

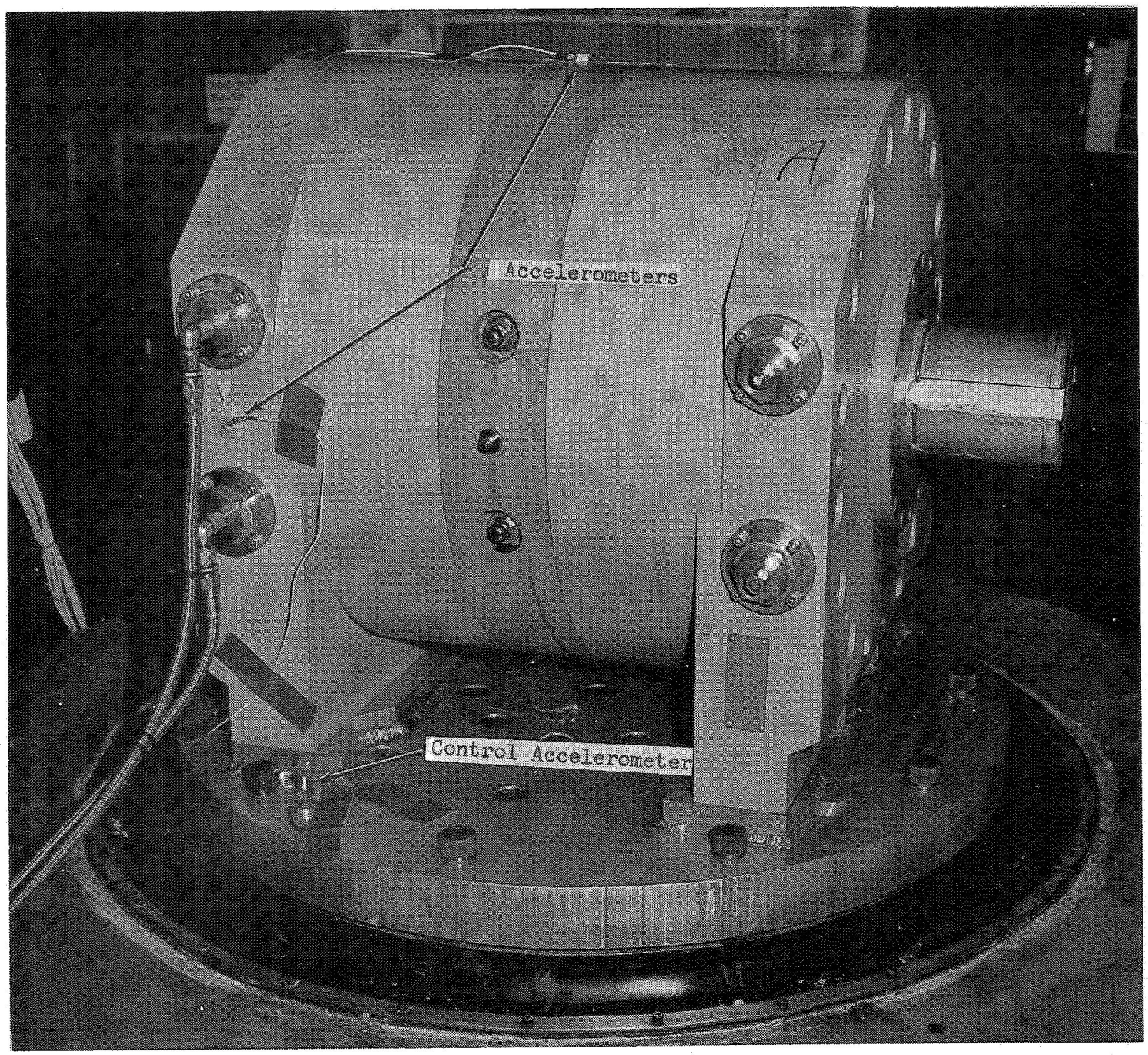


Figure 5-3. Vibration Test Setup, Y-Axis

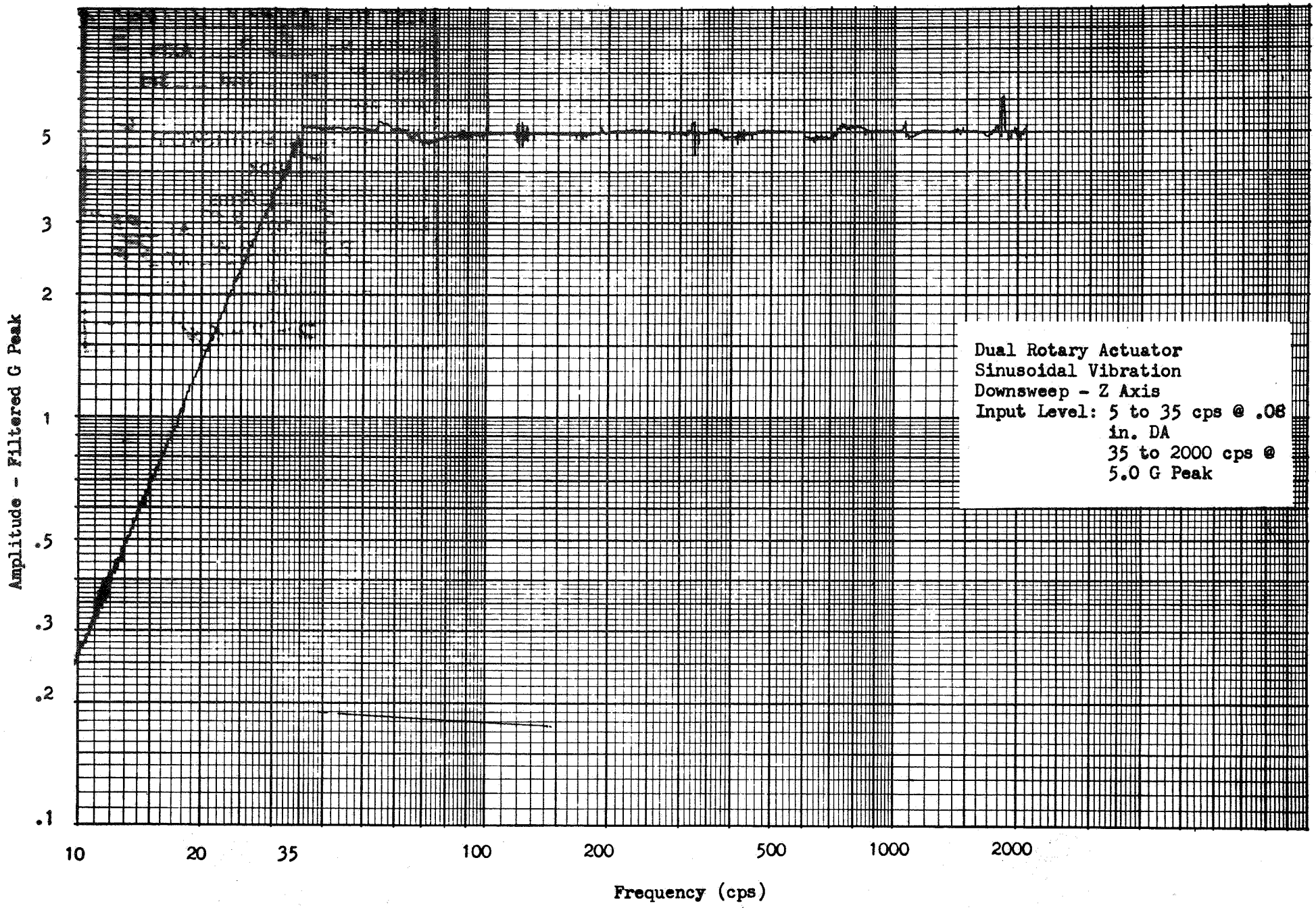


Figure 5-4. Typical Sinusoidal Vibration Plot - Control Accelerometer

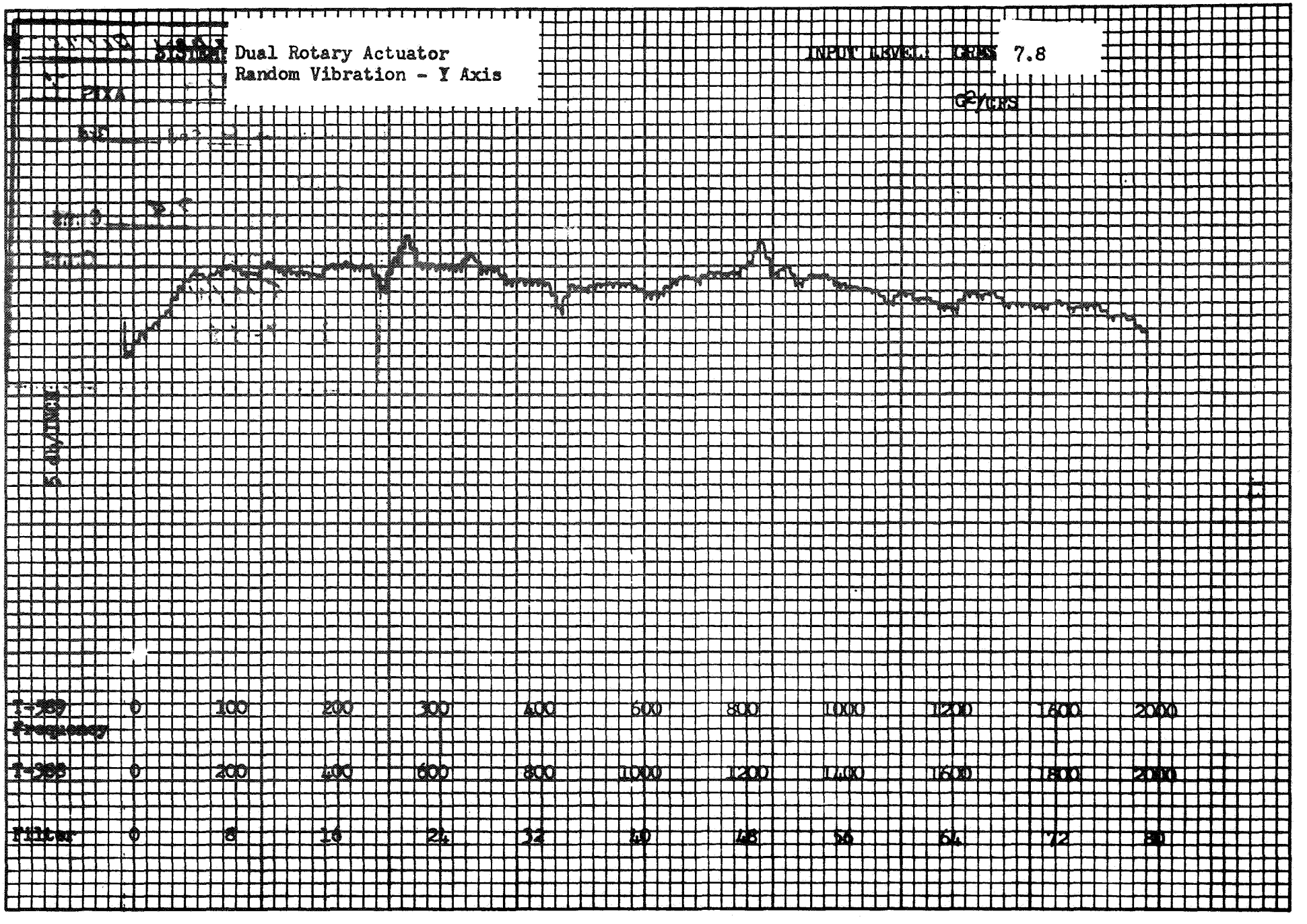


Figure 5-5. Typical Random Vibration Plot - Control Accelerometer

SECTION VI

IMPULSE TEST

6.1 TEST REQUIREMENTS

6.1.1 Using MIL-H-5606A hydraulic fluid as the pressure medium, pressurize each cell from 0 to 2250 to 0 psig at the rate of 35 cycles per minute. Each cell shall be subjected to 1000 cycles.

6.2 TEST PROCEDURE

6.2.1 The impulse test setup was assembled as shown in figures 6-1 and 6-2 utilizing the equipment listed in table 6-1.

6.2.2 All connections were tight, all gages were installed and operating properly, and all valves were closed.

6.2.3 The specimen was filled with hydraulic fluid and all trapped air was bled from the system. The specimen was locked in the 5 percent position.

6.2.4 Hand valves 3, 9, 15, and 18 and solenoid valve 16 were opened.

6.2.5 Accumulator 7 was pressurized to 2200 psig using regulator 4. Gage 8 was monitored.

6.2.6 Cycle timer 21 was started. Timing was adjusted on solenoid valves 10 and 26. Hand valve 25 was orificed to produce the pressure profile presented in figure 6-3.

6.2.7 The pressure profiles were recorded on oscillograph 22. 1000 cycles were performed on each cell.

6.3 TEST RESULTS

6.3.1 The internal bearing seals leaked intermittently during the impulse test at a rate of 2 cc per cycle.

6.3.2 During the post impulse functional test, no leakage occurred through the internal bearing seals. Leakage occurred in vane A as a result of the impulse test. A high of 1000 cc/minute was recorded at the 95 percent rotation position. Leakage dropped in vane B. A rate of 75 cc/minute was recorded at the 95 percent rotation position, compared to the 120 cc/minute recorded during the post vibration functional test.

6.4 TEST DATA

Test data are presented in table 6-2. A pressure impulse profile is presented in figure 6-3.

Table 6-1. Impulse Test Equipment List

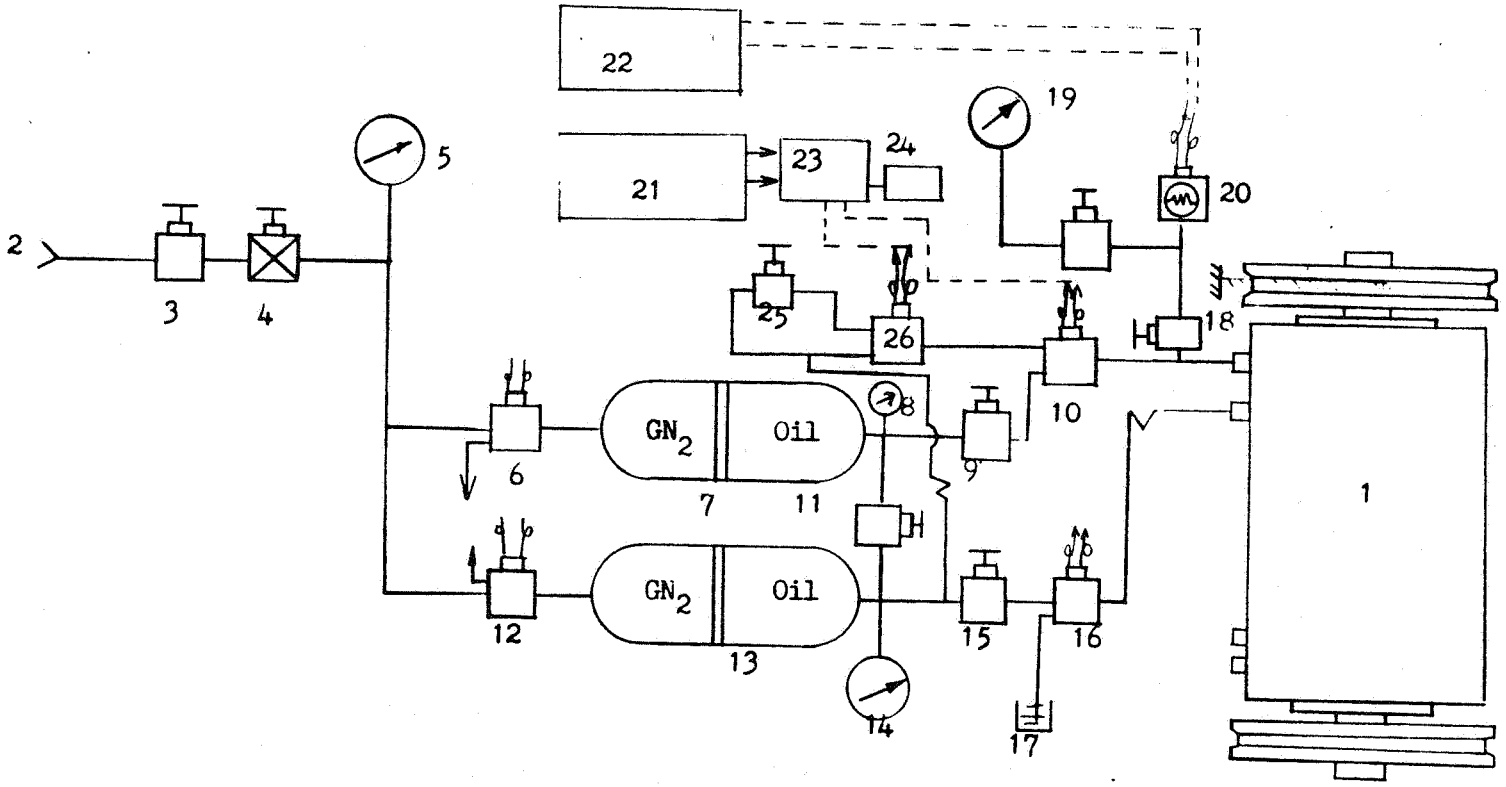
Item No.	Item	Manufacturer	Model Part No.	Serial No.	Remarks
1	Test Specimen	ExCello Corp.	S15X5X5	46798	
2	GN_2 Supply				3200 psig
3	Hand Valve	CPV			1-Inch
4	Pressure Regulator	Grove	18	L-43046	0 to 6500 psig inlet 0 to 6000 psig outlet
5	Gage	Ashcroft		NASA 200489-0	0 to 5000 psig Cal Date 8-9-67
6	Solenoid Valve	Marotta	MV-74	146	3-Way
7	Accumulator	Greer Hydraulics	SA-372		10-Gallon
8	Gage	Maximom		NASA 1231-B	0 to 3000 psig Cal Date 5-28-67
9	Hand Valve	Robbins Aviation	SSKG 375-B		1/2-Inch
10	Solenoid Valve	Marotta	MV-573H	913	3-Way
11	Hand Valve	Robbins Aviation	SSKG 250-14		1/4-Inch Fluid Transfer
12	Solenoid Valve	Marotta	MV-74	13766	3-Way
13	Accumulator	Greer Hydraulics	SA-372		10-Gallon
14	Gage	Marsh	100-4S	NASA 1202-B	0 to 3000 psig Cal Date 6-11-67
15	Hand Valve	Robbins Aviation	SSKG 375-B		1/2-Inch
16	Solenoid Valve	Marotta	MV-573H	912	3-Way

Table 6-1 (Cont'd). Impulse Test Equipment List

Item No.	Item	Manufacturer	Model Part No.	Serial No.	Remarks
17	Graduated Cylinder	Kimex			100-CC
18	Hand Valve	Robbins Aviation	SSKG 250-14		1/4-Inch
19	Gage	Hiese	H-35961	NASA 015537	0 to 5000 psig ± 1% FS Cal Date 7-22-67
20	Transducer	CEC		NASA 1162B	3000 psi Cal Date 6-6-67
21	DC Power Supply	Q-Nobatron	QR36-4A	NASA 015450	28-Volt, 5-Amps
22	O-graph	CEC	5-124	NASA 012589	Cal Date 8-8-67
23	Cycle Timer	Cramon Cont.	523	Y-23 89A	
24	Counter	Mercury			0 to 9999
25	Hand Valve	Robbins Aviation	SSKG 250-14		1/4-Inch
26	Solenoid Valve	Marotta	MV-573H		3-Way

TABLE 6-2. POST IMPULSE FUNCTIONAL TEST RESULTS

Vane Pressure (Psig)	Vane Position (% Rotation)	VANE A			VANE B		
		Torque (In-lbs)	Leakage (cc/minute)	Breakaway	Torque (In-lbs)	Leakage (cc/minute)	Breakaway
1500	5	112,000	800		129,200	75	
1500	25	105,800	850		128,200	95	
1500	50	105,000	650	510	125,800	120	
1500	75	125,000	1000		143,600	200	
1500	95	148,600	1000		152,000	205	



Note: All Hydraulic lines 1-inch
Pneumatic lines $\frac{1}{4}$-inch
Refer to table 6-1 for item identification.

Figure 6-1. Impulse Test Schematic

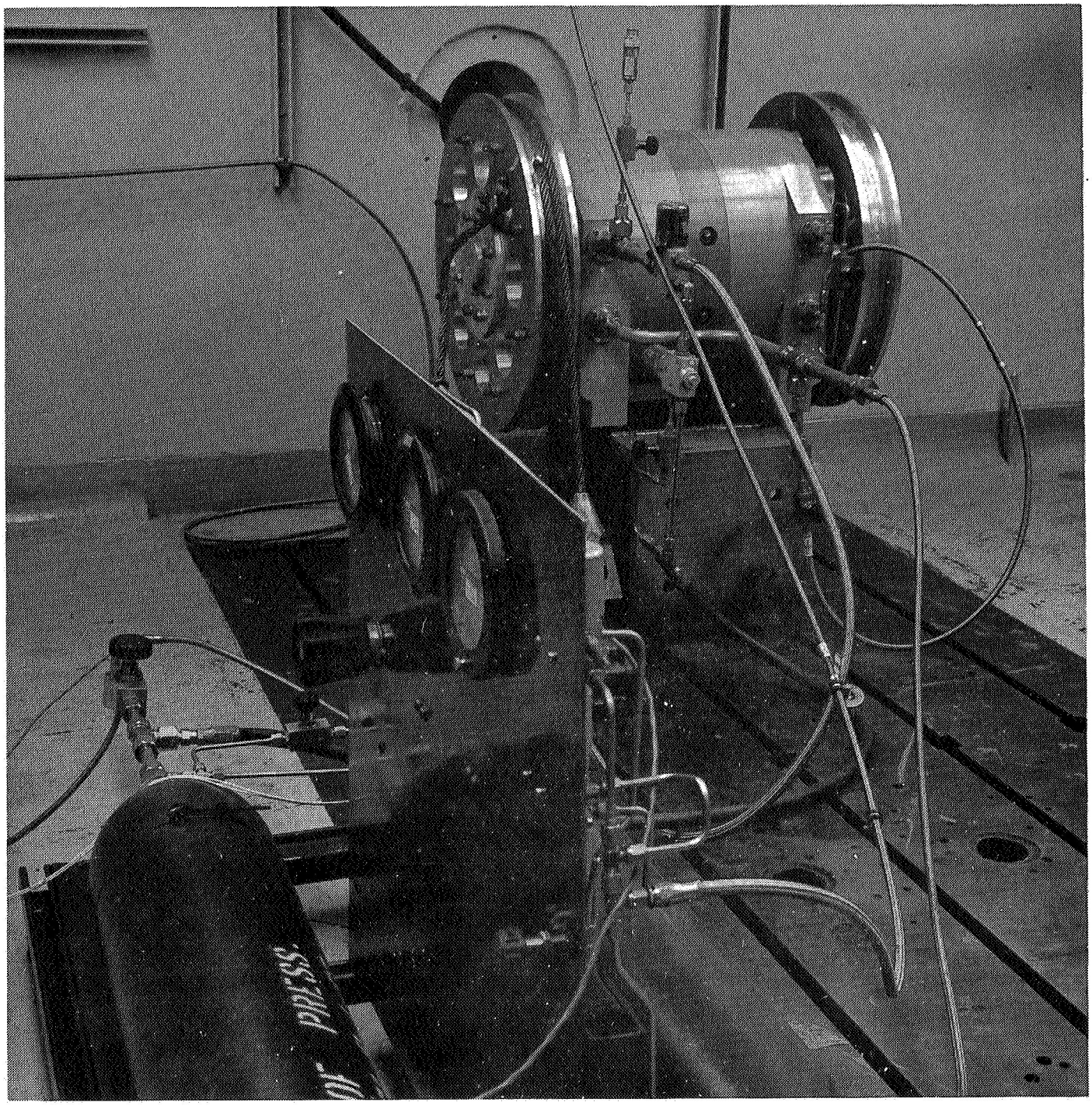


Figure 6-2. Impulse Test Setup

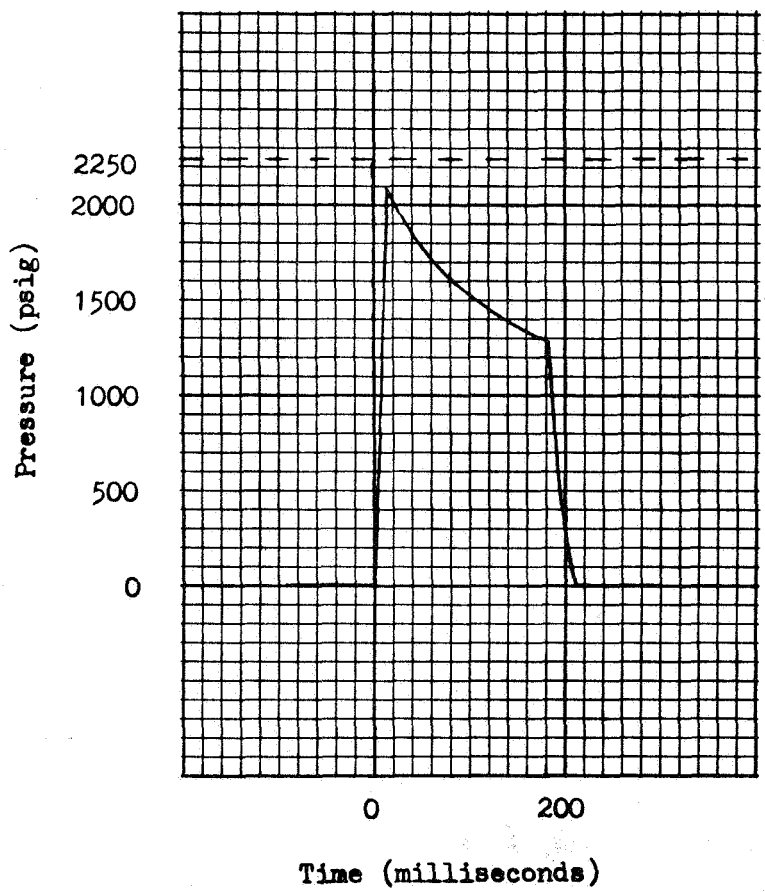


Figure 6-3. Typical Impulse Waveform

SECTION VII

LIFE CYCLE TEST

7.1 TEST REQUIREMENTS

7.1.1 The specimen shall be cycled through 90 percent of rotation, using MIL-H-5606A hydraulic fluid as the pressure medium. Operating pressure shall be 1500 psig and the specimen shall be loaded to 75 percent of the torque developed during the initial functional test. Perform 1000 cycles on each vane.

7.1.2 A functional test shall be performed after 50, 100, 250, 500, 750, and 1000 cycles.

7.2 TEST PROCEDURE

7.2.1 The life cycle test setup was assembled as shown in figure 7-1 utilizing the equipment listed in table 7-1.

7.2.2 All connections were tight, all gages were installed and operating properly, and all valves were closed.

7.2.3 Hand valves 3, 9, 15 and 20, and solenoid valves 10 and 16 were opened.

7.2.4 Accumulator 13 was pressurized. Vane A was rotated using vane B as a load. Lobes on the actuator pulleys were positioned to actuate micro-switches 23 and 24. Relay 22 selected accumulator 7 or 13 for direction of rotation.

7.2.5 Gage 21 was monitored. Loads of 1500 psig to 1350 psig were applied to the power vane.

7.2.6 Functional tests were performed at the end of 50, 100, 250, 500, 750 and 1000 cycles.

7.3 TEST RESULTS

7.3.1 Performance of vane A improved as a result of continuous cycling under load. A leakage rate of 350 cc/min was recorded at the end of 1000 cycles compared to the 1000 cc/min recorded at the start of cycling. Torque also increased slightly.

7.3.2 Leakage rates in vane B varied during the cycle test. However, leakage rates recorded at the beginning of cycling were very close to the leakage rates recorded after 1000 cycles. Torque remained approximately the same from the beginning to end of testing.

7.4 TEST DATA

Test data are presented in tables 7-2 through 7-7.

TABLE 7-1. LIFE CYCLE TEST EQUIPMENT LIST

Item No.	Item	Manufacturer	Model Part No.	Serial No.	Remarks
1	Test Specimen	Excello Corp.	S15X5X5	46798	
2	GN_2 Supply				3200-psig
3	Hand Valve	CPV			1-inch
4	Pressure Regulator	Grove	18	L-43046	0-to 6500-psig inlet 0-to 6000-psig outlet
5	Gage	Ashcroft		NASA 200489-0	0-to 5000-psig Cal. Date 8-9-67.
6	Solenoid Valve	Marotta	MV-74	146	3-way
7	Gas - Oil Accumulator	Greer Hydraulics	SA-372		10-gallon
8	Gage	Maximon		NASA 1231-B	0-to 3000-psig Cal. Date 5-28-67
9	Hand Valve	Robbins Aviation	SSKG 375-B		$\frac{1}{2}$-inch
10	Solenoid Valve	Marotta	MV-573H	913	3-way
11	Hand Valve	Robbins Aviation	SSKG 250-14		$\frac{1}{4}$-inch Fluid Transfer
12	Solenoid Valve	Marotta	MV-74	13766	3-way
13	Gas - Oil Accumulator	Greer Hydraulics	SA-372		10-gallon
14	Gage	Marsh	100-4S	NASA 1202-B	0-to 3000-psig Cal. Date 5-11-67
15	Hand Valve	Robbins Aviation	SSKG 375-B		$\frac{1}{2}$-inch
16	Solenoid Valve	Marotta	MV-573H	9-12	3-way

TABLE 7-1. (CONT'D.)

Item No.	Item	Manufacturer	Model Part No.	Serial No.	Remarks
17	Leak Sump				13-gallon
18	Solenoid Valve	Marotta	MV-74		3-way
19	Solenoid Valve	Marotta	MV-74		3-way
20	Hand Valve	Robbins Aviation	SSKG 250-14		$\frac{1}{4}$-inch
21	Gage	Heise	H-35961	NASA 015537	0-to 5000-psig $\pm$ 0.1% FS Cal. Date 7-22-67
22	Relay Switch	P and B	PR-11DY		24 Vdc DPDT
23	Limit Switch	Honeywell			SPDT
24	Limit Switch	Honeywell			SPDT
25	DC Power Supply	Q-Nobatron	QR-36-4A	NASA 015450	28-volt
26	Counter	Mercury			0-to 9999
27	Cable				5/8" Dia.
28	Block Assembly				
29	Block Assembly				

TABLE 7-2. POST 50 CYCLE FUNCTIONAL TEST RESULTS

Vane Pressure (Psig)	Vane Position (% Rotation	VANE A			VANE B		
		Torque (inch-pounds)	Leakage (cc/minute)	Breakaway (psig)	Torque (inch-pounds)	Leakage (cc/minute)	Breakaway (psig)
1500	5	120,500	50		122,000	240	
1500	25	118,600	35		118,100	180	
1500	50	120,200	130	350	122,000	150	325
1500	75	141,600	300		137,000	350	
1500	95	153,500	380		152,900	600	

TABLE 7-3. POST 100 CYCLE FUNCTIONAL TEST RESULTS

Vane Pressure (Psig)	Vane Position (% Rotation)	VANE A			VANE B		
		Torque (inch-pounds)	Leakage (cc/minute)	Breakaway (psig)	Torque (inch-pounds)	Leakage (cc/minute)	Breakaway (psig)
1500	5	121,000	420		121,000	315	
1500	25	110,500	---		114,000	155	
1500	50	117,800	90	340	120,100	125	325
1500	75	135,600	190		139,000	350	
1500	95	149,000	375		152,000	480	

TABLE 7-4. POST 250 CYCLE FUNCTIONAL TEST RESULTS

Vane Pressure (Psig)	Vane Position (% Rotation	VANE A			VANE B		
		Torque (inch-pounds)	Leakage (cc/minute)	Breakaway (psig)	Torque (inch-pounds)	Leakage (cc/minute)	Breakaway (psig)
1500	5	117,500	69		131,000	300	
1500	25	108,600	150		118,600	100	
1500	50	117,900	210	385	124,000	75	275
1500	75	120,100	600		144,600	600	
1500	95	158,100	1200		154,600	650	

TABLE 7-5. POST 500 CYCLE FUNCTIONAL TEST RESULTS

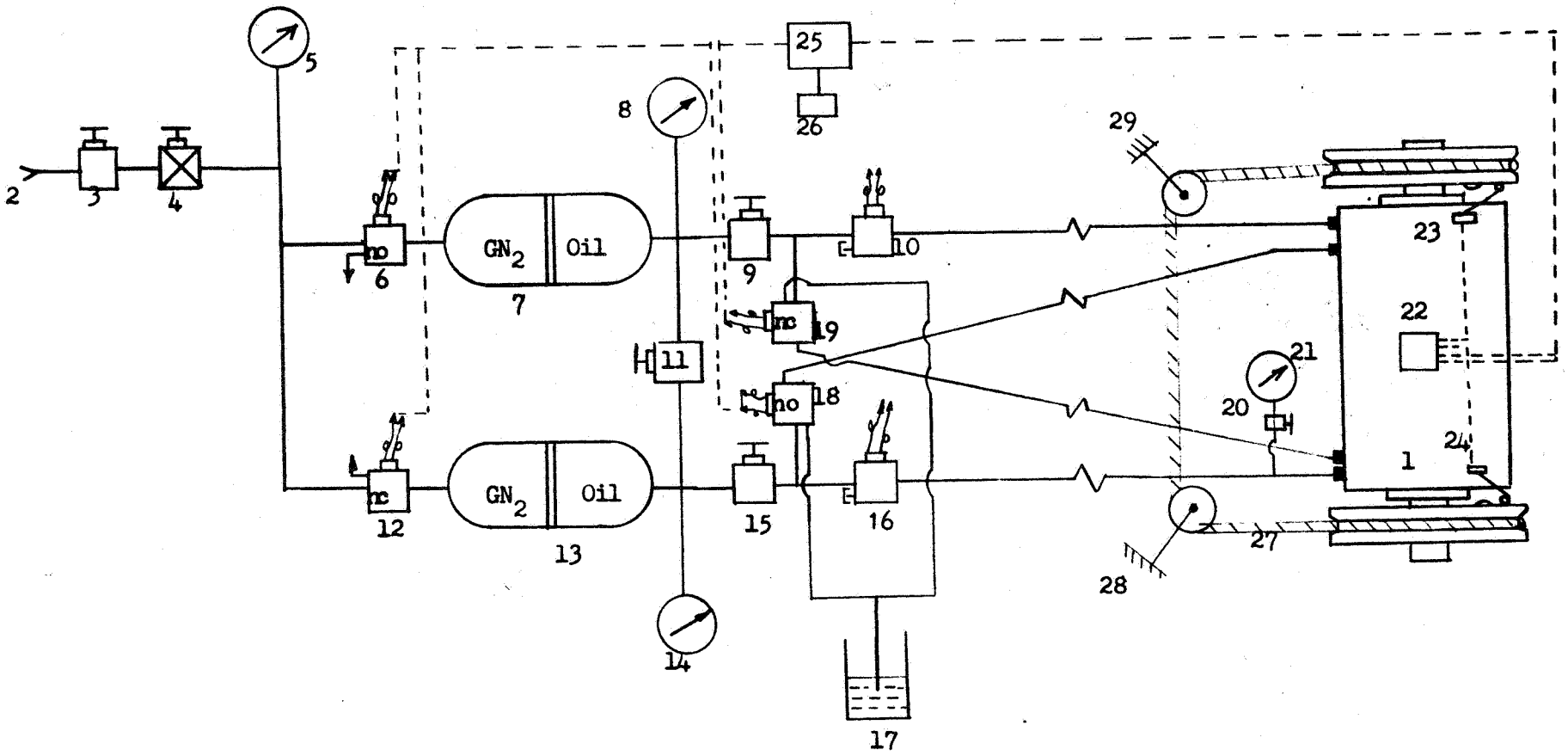
Vane Pressure (Psig)	Vane Position (% Rotation)	VANE A			VANE B		
		Torque (inch-pounds)	Leakage (cc/minute)	Breakaway (psig)	Torque (inch-pounds)	Leakage (cc/minute)	Breakaway (psig)
1500	5	118,100	350		126,300	225	
1500	25	110,000	250		119,700	205	
1500	50	113,250	500	425	126,600	250	275
1500	75	126,700	950		147,200	250	
1500	95	152,000	884		153,800	500	

TABLE 7-6. POST 750 CYCLE FUNCTIONAL TEST RESULTS

Vane Pressure (Psig)	Vane Position (% Rotation	VANE A			VANE B		
		Torque (inch-pounds)	Leakage (cc/minute)	Breakaway (psig)	Torque (inch-pounds)	Leakage (cc/minute)	Breakaway (psig)
1500	5	117,600	225		132,000	125	
1500	25	112,100	160		123,000	75	
1500	50	118,100	500	375	126,500	100	150
1500	75	136,000	450		141,000	150	
1500	95	150,500	500		150,000	350	

TABLE 7-7. POST 1000 CYCLE FUNCTIONAL TEST RESULTS

Vane Pressure (Psig)	Vane Position (% Rotation)	VANE A			VANE B		
		Torque (inch-pounds)	Leakage (cc/minute)	Breakaway (psig)	Torque (inch-pounds)	Leakage (cc/minute)	Breakaway (psig)
1500	5	118,100	110		135,000	100	
1500	25	109,500	75		127,600	105	
1500	50	116,400	200	370	130,500	110	165
1500	75	131,400	300		145,100	135	
1500	95	150,500	350		151,000	290	



Note: All hydraulic lines 1-inch
All pneumatic lines ¼-inch
Abbreviations: nc-normally closed
no-normally open
Refer to table 7-1 for item identification.

Figure 7-1. Life Cycle Test Schematic

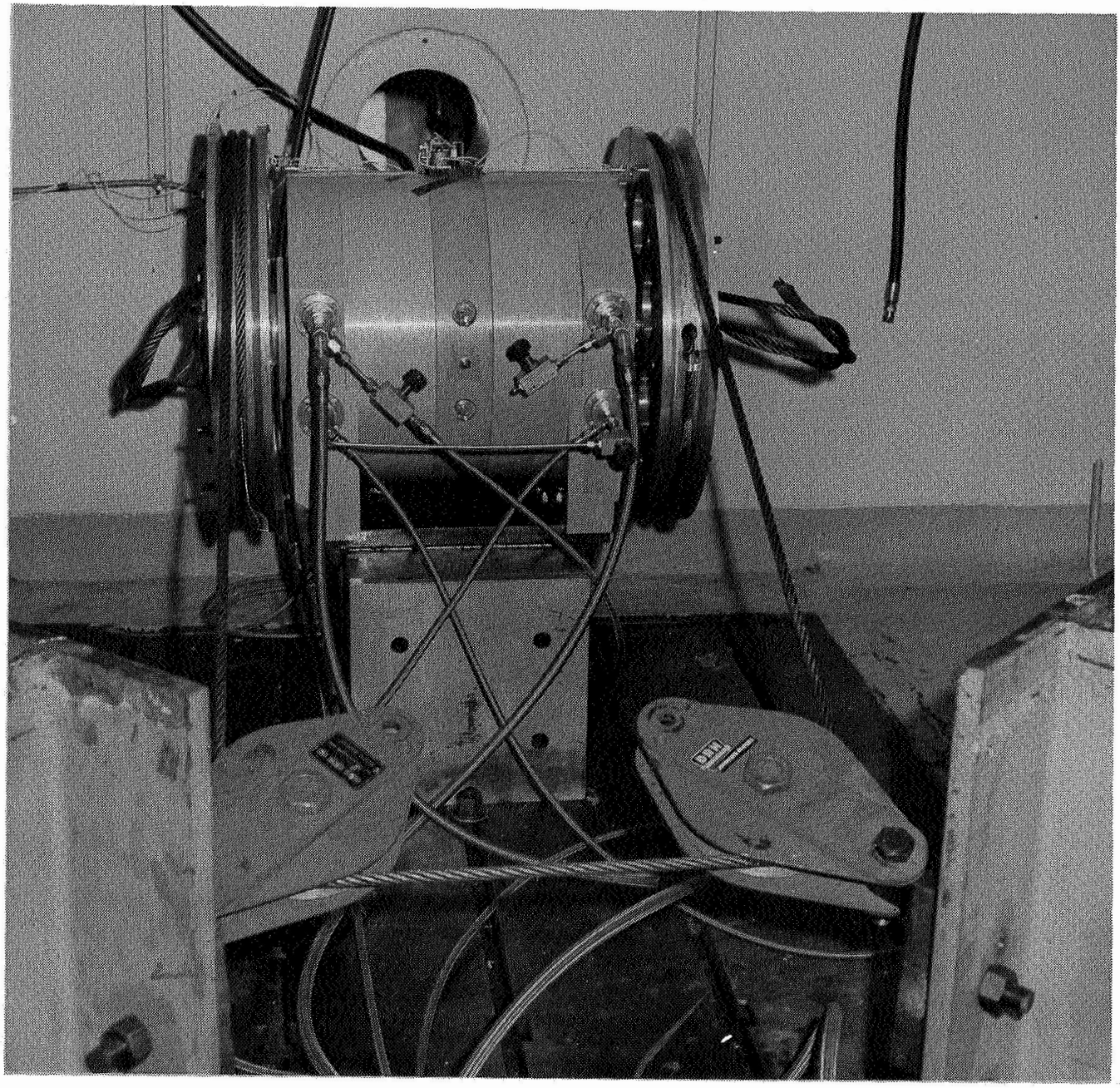


Figure 7-2. Life Cycle Test Setup

SECTION VIII

FINAL INSPECTION

8.1 TEST REQUIREMENTS

8.1.1 The specimen and plates shall be removed.

8.1.2 The specimen seals and bearings shall be inspected and photographed.

8.1.3 The end plates shall be reinstalled.

8.2 TEST PROCEDURE

8.2.1 The end plates were removed from the specimen.

8.2.2 The bearings and seals were inspected for damage and wear.

8.2.3 The specimen seals and bearings were photographed.

8.2.4 The end plates were reinstalled.

8.3 TEST RESULTS

8.3.1 Side A shaft "O" ring seal and one pressure port "O" ring seal were slightly damaged and worn. All other "O" ring seals and the vane seals appeared to be in good condition with a minimum of wear.

8.3.2 The cavity walls appeared to be in good condition, with a minimum of grooving and scratching.

8.4 TEST DATA

Photographs of the specimen are presented in Figures 8-1, 8-2 and 8-3.

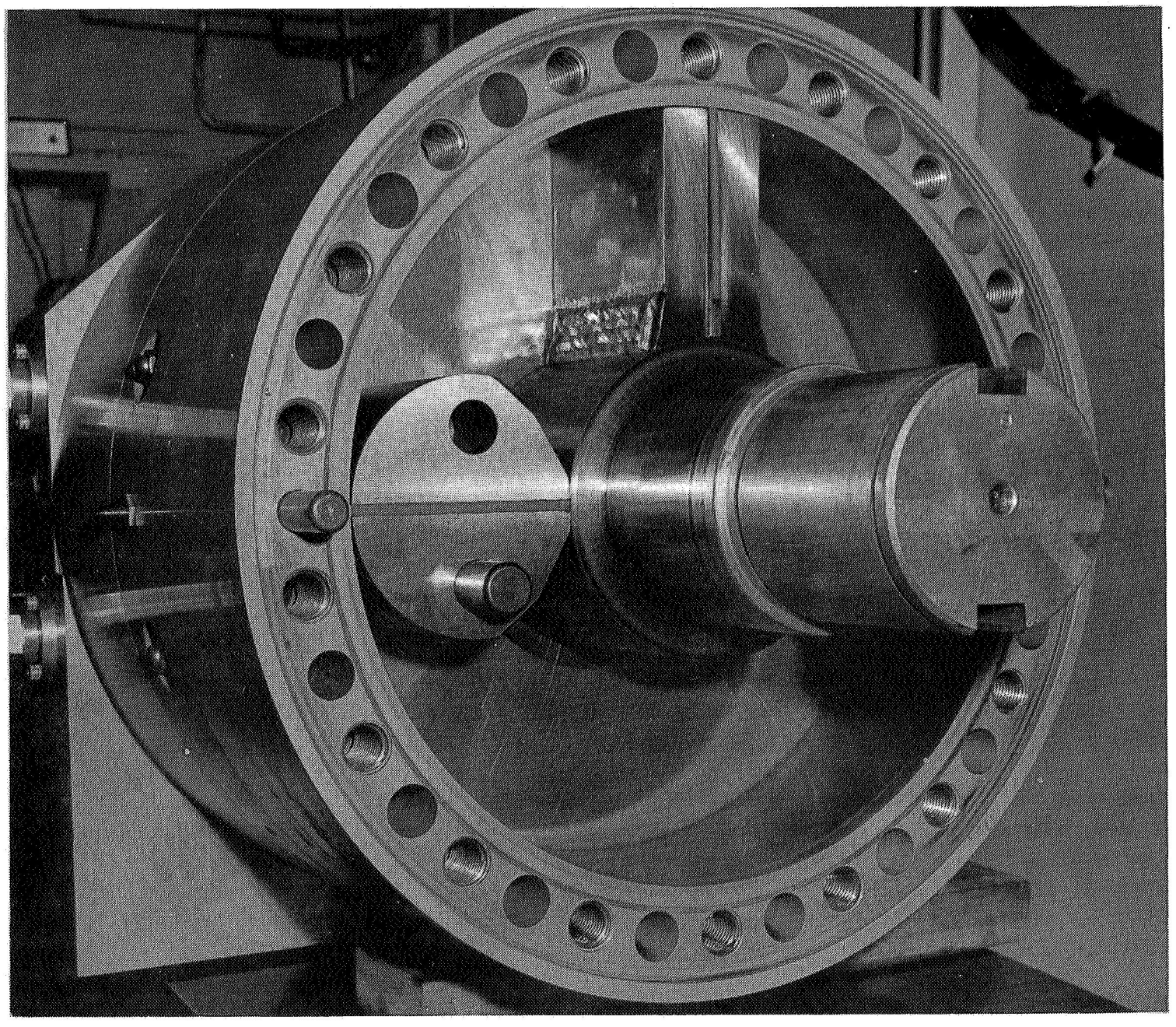


Figure 8-1. End View of Dissassembled Specimen

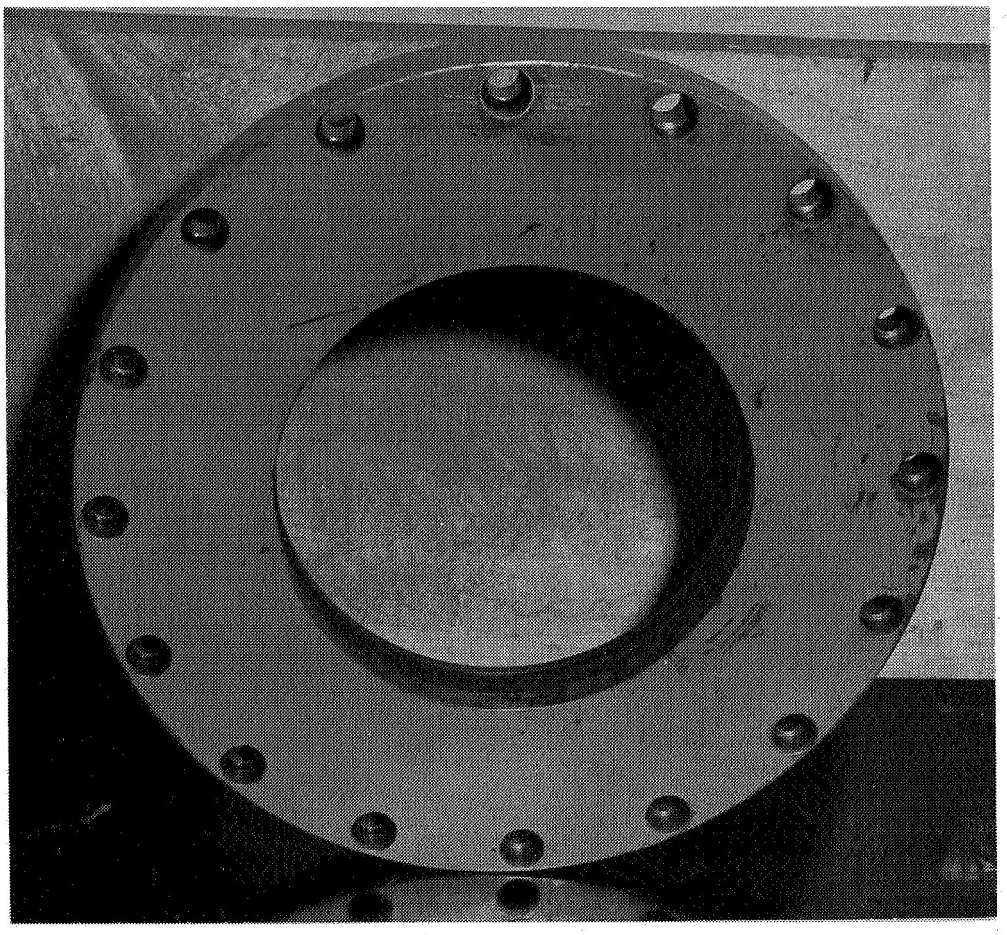


Figure 8-2. Specimen End Plate

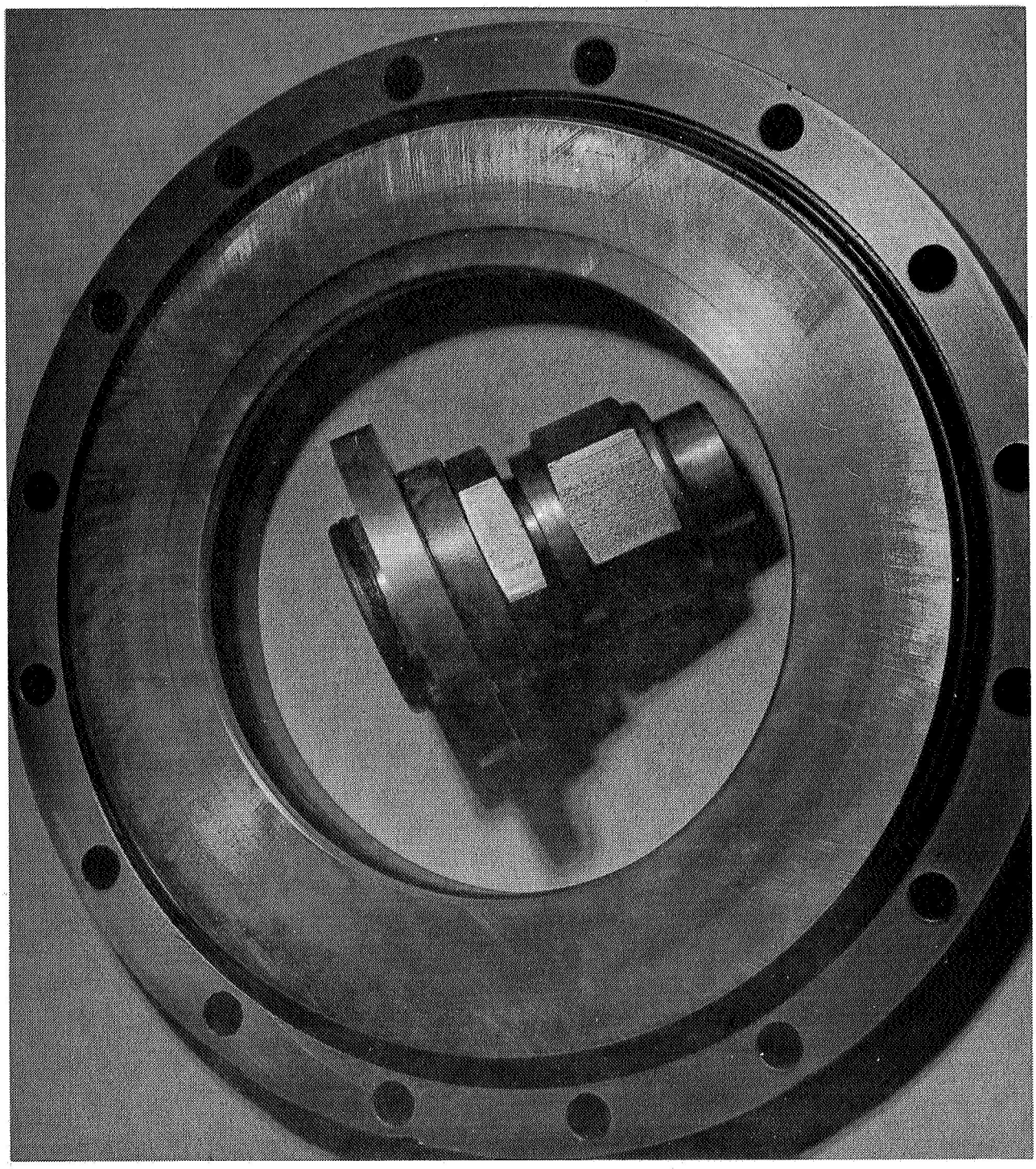


Figure 8-3. O-Ring Shaft Seal and Port Seal

APPROVAL

TEST REPORT

FOR

DUAL ROTARY ACTUATOR

EXCELLO CORPORATION MODEL NUMBER S15X5X5

NASA Drawing Number 75K26197

SUBMITTED BY:

for D. Hardwick

M. R. Watts
Test and Evaluation Section

APPROVALS:

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COMPONENT DATA	NASA DWG/SPEC/CODE NO.	FILE NO.
	75K26197, Revision A	GENERIC CODE D35101000018
	FIND NO. A9307	COMPLEX 34
	REF DESIG. NO.	SYSTEM Swing Arms
	PRIORITY IV	
NOMENCLATURE	MANUFACTURER	SUBSYSTEM
Actuator Dual Hydraulic Rotary	Excello Corporation	Hydraulic - Mechanical System
		NHA DWG. NO. 75K26326
CRITICALITY NO.	MFG MODEL NO.	STOCK CODE NO.
	S15X5X5IV	
CEI NO.	MFG PART NO.	REVISION: DATE 6/17/68
MAINTENANCE MANUAL	MFG DWG NO.	PREPARING ORGANIZATION
	SP-1155	Chrysler Corporation

SPECIFICATION REQUIREMENTS:

Service: Hydraulic Fluid, MIL-H-5606
Operating Pressure: 1500 psig
Proof Pressure: 3200 psig
Burst Pressure: 6000 psig minimum
Torque: 148,500 in-lb @ 1500 psi, each cavity
Rotation: 280° with 606.4 cubic inch displacement
Vane Leakage: 125 cc/min @ 1500 psi
Bearing Leakage: 10 cc/min @ 1500 psi
Breakaway Pressure: 200 psi max
Operating Temperature: 0°F to 160°F
Housing Material: Aluminum Alloy

FUNCTION:

The dual rotary actuator is used to rotate the umbilical swing arms from the launch vehicle.

ASSESSMENT & RECOMMENDATIONS:

The specimens satisfactorily completed the receiving inspection, proof pressure test, characteristics test, cycle test, and final inspection.

The rotary actuator torque requirements per the specification control drawing is 148,500 in-lbs. During the initial function test, the torque produced was within

(Continued on 2 of 2)

TEST HISTORY: Sheet 2 of 2

TEST REPORT NO.	TEST TYPE	REMARKS
TR-RE-CCSD-FO-1138-3	Receiving Inspection	Satisfactory
	Proof Pressure	Satisfactory
	Functional	Torque out of specification with vanes in center position.
	Characteristic	Satisfactory
	Vibration	Vane leakage of 700 cc/min in Vane A
	Impulse	Torque of 105,000 in-lbs with vane in 50% rotation position max leakage past vane A of 1000 cc/min
	Cycle	Satisfactory
	Final Inspection	Satisfactory

SERVICE HISTORY:

The dual rotary actuatory is a new part.

(Continued from 2 of 1)

the specification requirements with the vanes near the stops. However, this value decreased to a minimum of 132,000 and 134,900 in-lbs per vane midway through the actuator rotation.

Leakage and breakaway pressure discrepancies were encountered during various phases of the test. None of these were of a magnitude great enough to adversely effect system operation.

The specimen successfully withstood 1000 hydraulic impulse cycles, but the torque value in one cell dropped to 105,000 in-lbs in one position, which was the minimum value recorded during the test.

Although the specimen's performance deviated from the specification requirements during testing, none of the testing anomalies were of sufficient magnitude to effect its successful operation. System verification tests have been performed at MSFC on each swing arm. These tests verified that each arm will swing within the desired time. The rotary actuator is considered qualified for its intended use.